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A.R.P. Castings

Generally speaking, the iron foundry industry is not heavily engaged upon the production of armaments, or even castings for civil defence purposes. There is a large body of opinion which believes that the resources of the industry are being insufficiently utilised by the Government. They base their claims for the increased consumption of cast iron on the fact that the whole of its raw materials are available nationally, and this is obviously important from both the financial aspect and that of transport in time of war. With the enormous acceleration of the munitions production, an increasing demand is beginning to make itself felt for ancillary material, such as builders' castings to be used in the construction of new factories and the possible replacement of any damaged by air raids. One foundry, for instance, has a very large order for candlesticks! A large firm on the North-East Coast is now marketing cast-iron shelters to replace steel sheet, and its publicity matter makes out a very good case for their wide adoption. There should be no need to stress the permanence of cast iron, and consequentially upkeep costs are virtually eliminated. Because of the design of the shelters, they are both easily transported and erected. Erection is simplified because, being rigid, they are above ground and are covered with sand bags. The question of internal attachments is much simplified by reason of the internal flanges, whilst there is no limit, except that imposed by the dictates of commonsense, to their linear extension. Finally an excellent case is made out for their cheapness because of the high scrap value, which is negligible for steel and absent when concrete is used. Thus, regarded either as permanent or as temporary structures, cast-iron shelters have much to recommend them, whilst the fact that they are above ground minimises the trouble due to the percolation of water. Foundries at least should support their own industry when envisaging A.R.P. by ascertaining for themselves their potentialities. Foundries which are engaged upon the manufacture of municipal castings and those used by public utility undertakings should impress upon their customers the necessity for having large stocks which can be drawn upon in case of emergency. One well-known firm supplying the foundry industry has developed a hood, which also combines a spark-arrester, for masking the glare generated by the cupola. This is the type of activity which is worth emulation by the castings manufacturers.

The Toll of Accidents

An important Committee Report* relating to the rehabilitation of persons injured in accidents has just been published under the joint ægis of three Government Departments. The Committee has confined its attention in the main to fracture services, and has recommended that the treatment of fractures can only be carried out satisfactorily if cases are segregated into a specially organised department of a hospital and remain under its supervision until the restoration of full working capacity has been achieved. It is interesting to learn from the Report that of the 19,286 fracture cases investigated, 29.2 per cent. were due to industrial accidents, 14.9 per cent. to road traffic mishaps, and 55.9 per cent. to other causes. The loss to the community is stated to be "enormous" and "must run into many millions of pounds. The cost of the workmen's compensation under the Workmen's Compensation Acts . . . for the five years ending 1937 averages about £11,000,000 per annum." An efficient fracture service is recommended to include, in addition to the primary surgical treatment, proper facilities for treatment by physico-therapy and remedial exercises, so that the functional activity may be restored to the affected limbs. Centres should be established for this purpose, to be undertaken by the voluntary hospitals with increased financial support from the local municipal authorities. It is also recommended that the Government examine the possibility of a larger contribution, by way of additional benefits, being made by the Approved Societies to the hospitals which establish adequate fracture services. The Committee have called special attention to the expert service made available to civilians at the Queen Mary's Hospital for Limbless Men, Roehampton, for the fitting of artificial limbs.

* Final Report of the Inter-Departmental Committee on the Rehabilitation of Persons Injured by Accident. Published by H.M. Stationery Office. Price 3s. 6d. net.

Gating of Castings *

SECURING OPTIMUM FLOW

The Paper on "Gating with Special Reference to the Optimum Flow Conditions in the Molten Metal," presented by Dr. E. M. H. Lips to the recent International Foundry Congress in London, has been the subject of some written discussion, which is reproduced below. The Paper was printed in our June 15 issue.

Mr. W. E. Styles (Austin Motor Company) wrote that he was in full agreement with Dr. Lips regarding the use of small downgates. In his opinion, the use of one or more small, instead of one large, downgate was the surest means of ensuring a clean casting. There were two points in the Paper, however, from which the writer found it preferable on occasion to

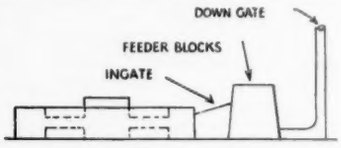


Fig. A.

differ:—(1) That a pouring gate should not be combined with a riser; and (2) that there should be no increase in the cross-section of the gate.

With reference to (1), a riser was added to the mould, chiefly for feeding purposes, and although the writer did not agree with the practice of pouring the metal through a riser, he had had considerable success by incorporating the feeder in the runner system.

The method employed would readily be understood by referring to Fig. A. The casting is a gear blank, and much trouble was experienced with sinking in the centre boss unless a riser was added. This riser the writer wished to avoid, chiefly on account of extra dressing costs. Occasional trouble was also found with slight porosity at the root of the teeth after the castings had been machined. The application of the feeder block corrected both the above defects.

(2) Regarding the increase in the cross-section of the gate, this was an essential part of the

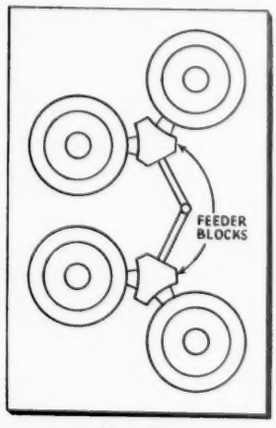


Fig. B.

feeder block principle. The downgate and channel *must* be of a smaller cross-section than the ingate from the feeder block to the casting. The reason for this was that the channel must solidify before the ingate to enable the molten metal in the block to feed into the casting and not back into the channel. Although only one casting had been described, the method had been applied to numerous others with excellent results.

Fig. B illustrated a typical pattern-plate layout.

Mr. Styles concluded his comments by tendering his thanks to Dr. Lips for the opportunity provided of reading a very interesting and instructive Paper.

Dr. E. M. H. Lips, in reply, wrote that to comply with the hydrodynamic theory, the downgate must be of a thin and regular cross-section. One would like to subject even the shape of a casting to the same reservations. This latter would be impossible in many cases, of course, which caused an ungovernable flow of the metal from the moment it entered the mould proper.

Referring to Figs. A and B, he suggested that one should look upon the riser as an integral part of the actual casting, thereby showing that there was no real contradiction in Mr. Styles' explanation of the phenomena and the author's. The same applied with reference to a sudden change in the cross-section. It stood to reason that full advantage of the application of the hydrodynamic laws could only be had when one bore in mind this principle in the design of the casting.

Publications Received

Proceedings of the Third Annual Conference of the Combustion Appliance Makers Association (Solid Fuel). Published from the offices of the Association, 54, Victoria Street, London, S.W.1.

The really interesting part of this Conference, which was presided over by Mr. W. Rennie (chairman of Federated Foundries, Limited), was the question as to how the manufacturers of stove grates and cookers burning solid fuel could create a sales organisation comparable with those handling either gas or electrically heated apparatus. As both the gas and electric companies act as sales agencies for the foundries making heating and cooking apparatus, there is a search for some organisation capable of not merely selling, but also of servicing the apparatus sold. It is the reviewer's experience that it is difficult to obtain reliable technical advice (except from the distant manufacturer) as to heating efficiency or control of apparatus when using solid fuel. Moreover, for the installation of central heating, two types of operatives are apparently required—the plumber and the pipe fitter. Handling of the fuel and servicing of the apparatus are still major problems. These and many other problems are dealt with in the 400-page report of the Conference.

A.R.P. in Industry

A pamphlet on "A.R.P. in Industry," explaining the Civil Defence Act, has been prepared by the Lord Privy Seal's Department for the guidance of owners and occupiers of industrial and commercial establishments. It is a revised and amplified description of the Act, replacing the pamphlet bearing the same title which was issued at the time this measure was introduced into Parliament.

The Act lays important obligations on owners and occupiers of commercial establishments in vulnerable areas specified in the Act where more than 50 people are employed, and creates other obligations in regard to such establishments where more than 30 people are employed in any part of the country. The leaflet is therefore of great importance to the majority of employers of labour.

The new pamphlet has been printed in large quantities, and copies may be obtained, free of charge, on application to the Publicity Section, A.R.P. Department, Horseferry House, Thorney Street, London, S.W.1.

Catalogue Received

Aluminium Alloys for Shipbuilding and Marine Engineering. The Northern Aluminium Company, Limited, of Bush House, Aldwych, London, W.C.2, have prepared a "Sales Engineering Bulletin" specially addressed to naval architects, in which a series of alloys is indicated as being suitable for incorporating in new designs of ships to cut down weight.

Random Shots

On every hand and with both ears we hear that this is the age of flying, for nowadays the noise of the aeroplane comes near to outdinning the hoot and clatter of motor traffic. Low over the chimney-pots swoop these modern means of transport and pit-a-pat goes the householder's heart as he listens to the rush of their flight. Truly we are getting on!

* * *

But in August flying takes on a deeper significance, and a different note is struck. So incidentally are a number of other things when "Marksman" gets busy with his fly swatter, which may consist of anything handy, whether it be a putter or a pole-axe. Yes, hunting the fly may well be numbered among the blood sports even though the hunter loses a good deal more blood than the hunted.

* * *

Less ardent spirits prefer to go after the fly with a trap, and eschewing such heavy artillery as dictionaries and doormats, they hie them to a chemist and lay in a store of sticky papers and whatnot calculated to persuade the fly that if you want to make a success of a thing you must stick to it. This advice, although admirable in itself, need not be taken too literally, for "Marksman" remembers an occasion . . .

* * *

From the kitchen regions came an S O S for help against a plague of flies, and "Marksman," never recking in his ardour of the who and the why of the matter, flew to the rescue. This was a runner-up to the plagues of Egypt, for flies stood on each other on the ceiling and the squash was terrific—really a most unpleasant state of affairs.

* * *

Plentifully adorned with fly bands, a cunning contraption which when gently heated unrolls, or should, at any rate, and provides about a yard of intense stickiness guaranteed to ensnare an elephant or thereabouts, "Marksman" prepared for action. Actually there was a hold-up, for the first consignment of fly bands were over-annealed on the kitchen stove and burst into flames. And the smell! There was talk of drains for days afterwards.

* * *

Just what went wrong in the final stages of the assault it is hard to say, but wisdom suggests on reflection that it would have been wiser to unroll the bands *after* mounting the step ladder. It was perhaps reckless to carry two in each hand for one's balance is as a rule no better on a pair of steps than it is at the bank. But, alas, the best of foundrymen must sometimes founder.

* * *

Of the stickiness of those fly bands there cannot be any question. When the step ladder began to wobble one was already hung up and it took an affectionate grip of "Marksman's" hair. Of the others, two attached themselves to his trousers, while the fourth clung to his coat. And all the while the wobble grew in intensity until the end came with a horrible crash.

* * *

The doctor who bandaged up the bruises and abrasions looked in yesterday. He left with the remark: "You should do something to get rid of the flies here."

"Marksman."

Copper and Copper-Alloy Castings for Electrical and Thermal Conductivity Applications*

By H. J. MILLER,† M.Sc.

Introduction

One of the outstanding features of copper is the possession of high electrical and thermal conductivity, and on this account the metal finds extensive industrial application, especially in wrought forms such as strip, sheet, wire, rods and sections. The demand for high-conductivity castings is, however, limited, and, indeed, when it is desired to employ castings for electrical and thermal conductivity applications, there are many difficulties both in the choice of composition and in founding.

The production of foundry castings in essentially pure copper has always presented great difficulties, and it is perhaps true to say that the problem has been mastered only by a few specialists. Certainly the project has not been undertaken by the average foundry, and the reasons for the limited interest in copper castings are not far to seek, since, in addition to the founding troubles, it is to be noted that cast copper is not characterised by good mechanical properties, these being, in fact, inferior to those of all copper alloys.

For this reason, it is only in cases where, primarily, high conductivity (thermal or electrical) is required that copper castings are seriously considered. One important application of a thermal character is that of blast-furnace tuyeres, for which copper containing about 1 per cent. tin is generally used; the main application involving electrical conductivity is in connection with various parts for switchgear and other plant in the electrical trades. In practice the range of alloys used for electrical castings is extremely wide and includes brasses, bronzes and other copper alloys. One of the objects of the present Paper is to summarise the alloys now being regularly employed or which are now available for special-purpose castings; this has been undertaken because of a general desire on the part of users for a summarised statement on the latest developments pertaining to the special high-conductivity and high-strength alloys which have become available within recent years.

The Paper is divided into several sections as follows:—

PART 1.—Tough pitch copper—effect of oxygen—effect of hydrogen—reactions on solidification—properties of tough pitch copper—oxygen-free copper.

PART 2.—Deoxidised copper—consideration of deoxidants—properties of deoxidised copper castings.

PART 3.—Commercial copper-rich casting alloys.

PART 4.—Modern high-conductivity high-strength casting alloys—copper containing chromium additions—other alloys.

PART 5.—Foundry technique.

PART I.—TOUGH PITCH COPPER

For an appreciation of the factors involved in the casting of copper, it has been considered advisable to outline briefly the present state of knowledge with regard to the reactions occurring in the production of "tough pitch" copper. Such copper always contains a small amount of oxygen—generally within limits of 0.02 to 0.08 per cent.—and it is the conventional form of copper for casting into billets, cakes, ingots and other shapes in which the metal is marketed for fabrication purposes. In the course of the usual refining of the metal for such purposes, it is exposed to the various gases which are present in the furnace atmosphere, and there is consequently a considerable absorption of certain of these gases, notably oxygen and hydrogen. These subsequently give rise to reactions on solidification of the molten metal, with some resulting unsoundness in the final cast shapes. With this tough pitch copper, the unsoundness is always of a controlled order, and, in fact, the term "tough pitch" is applied to products which exhibit unsoundness only to such an extent that the evolution of gases exactly counterbalances the natural shrinkage effect; this unsoundness has no deleterious influence in the case of cast products for fabrication, since the porosity is removed in the hot-working stages.

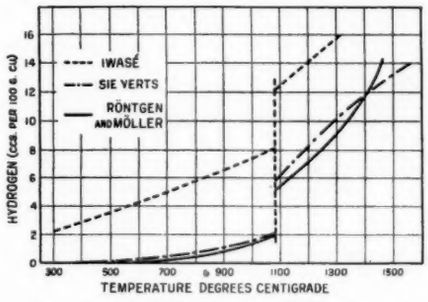


FIG. 1.—SOLUBILITY OF HYDROGEN IN COPPER.

The elucidation of the actual effects of oxygen and hydrogen in the casting of copper is largely due to Allen and his colleagues[1] in this country and to the American Metal Company[2] in the U.S.A., and in this Paper only a brief description of the reactions will be attempted. Further, it is not possible to consider here the related factors of pouring temperature of metal, temperature of moulds, shape of moulds and cooling rates, all of which affect the rate of gas evolution.

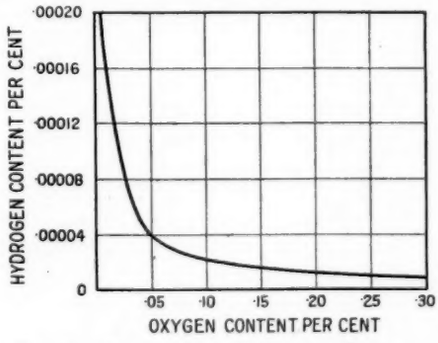


FIG. 2.—VARIATION OF HYDROGEN CONTENT OF MOLTEN COPPER AT 1,150 DEG. C. WITH OXYGEN CONTENT.

While it might be thought that there would be little similarity between melting conditions existing in large-scale refining furnaces and those in small foundry furnaces, there is no fundamental difference, and the need for appreciation of the gaseous reactions is certainly necessary in both cases.

Effect of Oxygen

Oxygen enters into chemical combination with molten copper, forming cuprous oxide, and in cast metal practically the whole of the oxide exists in the form of a copper-cuprous oxide eutectic, since the solid solubility limit is extremely low; the eutectic composition corresponds to approximately 0.39 per cent. oxygen. In wrought products, the eutectic type of structure is broken up, so that the oxide then exists in the form of separate particles of cuprous oxide. Within the usual commercial limits the oxide, as present in wrought tough pitch copper, has little or no effect on mechanical or other properties, although copper which is free from such oxide is characterised by slightly superior ductility.

Effect of Hydrogen: Reactions on Solidification

Hydrogen is simply absorbed or dissolved by copper so that it exists in the uncombined state; the extent to which it is soluble depends both on the temperature and the oxygen content of the metal. On heating, there is a gradual increase in the amount of hydrogen absorbed by the solid metal and on reaching the melting point there is a marked increase in solubility, while at higher temperatures a further increase in solubility is encountered. Some results by various investigators are reproduced in Fig. 1, from which considerable differences will be noted; the curve shown as a continuous line is the most recent determination.[3]

The amount of hydrogen which can dissolve in molten copper at any temperature is also a function of the oxygen content, and with molten copper which is high in oxygen, only a limited amount of hydrogen is dissolved, owing to the fact that immediate reactions occur with some of the oxygen present; with molten copper of low oxygen content it is possible to obtain an appreciable solubility of hydrogen in accordance with Fig. 1. A curve reproduced from Allen's Paper is given in Fig. 2, and this expresses the general change in solubility at 1,150 deg. C. of hydrogen in copper containing various amounts of oxygen. The change in the curve of hydrogen solubility when the oxygen content is of the order of 0.05 per cent. is especially noticeable, and the refiners' art in obtaining the tough pitch condition in copper is thus seen to be related to the balance between oxygen and hydrogen contents. The curves given in the Patents of the American Metal Company are very similar in character, although quantitative results were not given, only the fundamentals attaching to the influence of gases on molten copper being established, these being based essentially on principles enunciated by Hofman[4] in 1914.

The liberation of the excess hydrogen from solution on solidification of the metal is accompanied by a reaction with cuprous oxide according to the equation:—

$$Cu_2O + H_2 \rightleftharpoons 2\,Cu + H_2O.$$

This reaction, occurring during solidification, results in disturbance and expansion of the metal. The extent of the reaction depends mainly on the amount of hydrogen contained in the molten copper, since there is usually sufficient cuprous oxide present to react with the whole of the hydrogen liberated; however, certain other factors are also involved. The tough pitch state—with expansion due to gas evolution equalising the natural shrinkage—is normally obtained within an oxygen range of about 0.025 to 0.08 per cent. With lower oxygen contents a more extensive reaction is encountered, giving markedly unsound products, simply on account of the greater quantities of hydrogen which were in solution in the first place; with higher oxygen contents the casting surface sinks in the mould, but the metal is then deficient in ductility.

Properties of Tough Pitch Copper

It will be appreciated from the foregoing that "tough pitch" copper is not completely sound, although the porosity, amounting to 2 to 5 per

* Paper presented to the International Foundry Congress held in London and organised by the Institute of British Foundrymen.

† Copper Development Association, London.

cent. by volume for most simple cast shapes, is, as already explained, removed in the early stages of hot-working. For ordinary castings, however, it is obvious that the gas reactions associated with tough pitch copper will be most undesirable, and attempts to cast such copper into sand moulds almost invariably culminate in disaster.

It must be pointed out, however, that many simple cast shapes are made in tough pitch copper by pouring into chill moulds. These should preferably present an open surface and, if maximum density and mechanical properties be required, the castings should afterwards be forged. By this means it is possible to obtain

(Courtesy T. Bolton & Sons, Limited.)

Fig. 3.—Casting Tough Pitch Copper for Production of Terminal Castings.

small products having good density and an electrical conductivity ranging between a minimum of 90 per cent. and about 97 per cent. Figs. 3 and 4 show some products made in this manner. The properties of cast tough pitch copper are summarised in Table I and, in order to appreciate the effects due to porosity, figures are also quoted for this material in a lightly-forged and in the usual heavily-worked annealed condition.

Oxygen-Free Copper

To obtain molten copper in such a condition that gas reactions on solidification are avoided, it will be clear from the foregoing consideration that the courses open to experiment are (1) elimination of oxygen or (2) elimination of hydrogen. The latter method is generally impossible of fulfilment owing to practical difficulties following on the fact that hydrogen can be derived from water vapour present in

Table I.—*Properties of Tough Pitch Copper.*

	Cast.	Lightly-forged castings.	Worked and annealed.
Density	8.4	8.85	8.93
Tensile strength, tons per sq. in.	9	13	13.5
Elongation, per cent. on 2 in.	20	40	60
Reduction of area ..	20	40	75
Brinell hardness ..	32	35–40	45
Electrical conductivity, per cent. ..	80–85	95	100–102

the furnace atmosphere. Hence, the general course is to attempt the elimination of oxygen by the addition of elements which are capable of reacting with cuprous oxide, thereby forming liquid or solid products which may be slagged-off; this method is dealt with in Part 2.

In the Patented process which has been commercially developed for the production of oxygen-free high-conductivity copper billets and vertically-cast cakes, melting of the copper is performed in inert gas atmospheres (carbon monoxide and nitrogen) and the molten metal is conveyed into the moulds under cover of the same gases. The resultant cast shapes are free from both oxygen and porosity due to dissolved gases, and they thus have a high density (an average of 8.9); on account of freedom from gas reactions on solidification, the normal shrinkage of gas-free molten metals is exhibited, while another feature is the possession of a relatively coarse structure. Although a considerable tonnage of copper is cast into simple shapes for fabrication purposes, it is not possible to envisage the application of this technique to the production of miscellaneous sand castings. However, the time may yet arrive when non-ferrous foundries will be in a position to conduct melting and casting processes *in vacuo* or in inert atmospheres; such equipment would eliminate hydrogen absorption, which with present methods of producing deoxidised copper remains as a potential cause of porosity.

PART 2.—DEOXIDISED COPPER

A consideration of the fundamental requirements of a deoxidant will not be attempted, but in addition to the usual factors, special attention must be given to the effect of residual quantities of deoxidants on both electrical and thermal conductivities, which are closely allied. The fact that small quantities, *i.e.*, about 0.1 to 0.2 per cent., of certain elements may reduce conductivity to one half of the original value is not always fully appreciated, although it is obviously of prime importance in connection with castings for conductivity applications. In order to clarify the position from this aspect some results of conductivity determinations are graphically presented in Fig. 5.

From the point of view of materials the principal points to be noted in the production of castings having maximum conductivity are:—

(1) The use of high-grade copper (H.C. quality) and avoidance of contamination with impurities.

(2) The choice of a deoxidant having little adverse effect on conductivity or alternatively the use of minimum quantities of more harmful deoxidants.

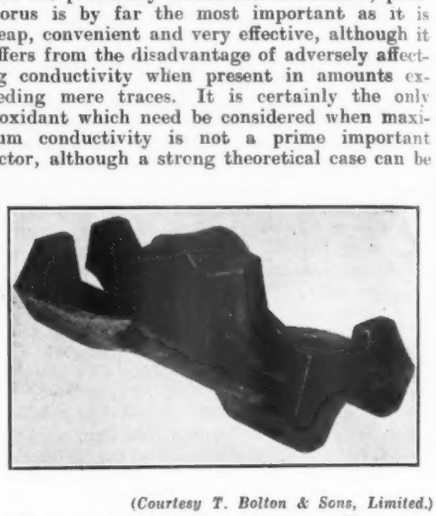
A surprisingly large number of recommendations concerning deoxidants for high-conductivity copper castings have been advanced over a period of many years, and in some cases extravagant and unsubstantiated claims have been put forward. This might perhaps be taken as an indication of the difficulty of the problem. At any rate, the choice of deoxidants was being vigorously discussed about thirty years ago, when it is interesting to note that boron carbide was first used[5] and that calcium was patented for deoxidation purposes.[6] During the intervening years other special deoxidants have been introduced so that to-day the choice is extremely wide; the practice advocated by different investigators has been so varied as to cause much confusion, and hence it is difficult to deal with this matter in a completely satisfactory manner.

Deoxidants which have received some consideration include aluminium, beryllium, boron, boron carbide, cadmium, calcium, calcium boride, lithium, magnesium, phosphorus, silicon, titanium and zinc, although not all of these have been used on a commercial scale. Quite frequently a combination of two deoxidants is recommended.

A fact which must not be forgotten when making deoxidised copper castings is that hydrogen can be present in considerable quantities in the molten metal; it is believed that this accounts for many of the variable results which have been reported. Even at the present time it must be confessed that everything is not known concerning the solubility of hydrogen in various deoxidised coppers in the molten and solid states. For instance, there is some indirect evidence leading to the conclusion that the presence of deoxidants (or certain of them) results in diminished hydrogen solubility in the liquid state, or that the solid solubility is much greater, while an alternative idea is that the evolution of the gas on solidification takes place without any harmful results. The number of occasions on which "hydrogen unsoundness"—as apart from the "reaction unsoundness"—is obtained with deoxidised copper are relatively few, but this possibility must not be overlooked.

Consideration of Deoxidants

Of the previously mentioned deoxidants, phosphorus is by far the most important as it is cheap, convenient and very effective, although it suffers from the disadvantage of adversely affecting conductivity when present in amounts exceeding mere traces. It is certainly the only deoxidant which need be considered when maximum conductivity is not a prime important factor, although a strong theoretical case can be



(Courtesy T. Bolton & Sons, Limited.)

Fig. 4.—Lightly-Forged Tough Pitch Copper Casting for Electrical Switchgear.

presented on behalf of silicon, as, for instance, in wrought copper for welding, on account of the reduction of hot-cracking tendencies.[7]

For general castings, a residual phosphorus content of 0.05 per cent. may be regarded as a satisfactory figure to be aimed at, this amount normally being sufficient to ensure complete deoxidation. However, for pressure-tight castings, such as tuyeres, copper containing this amount of phosphorus does not appear to be entirely suitable, since porosity has been reported with products made from such material; the reasons for this are not too clear, but the trouble is most probably due primarily to excessive gas absorption during melting.

For blast-furnace tuyeres and other castings which are required to withstand a hydraulic test at a pressure of 60 lbs. per sq. in., most founders

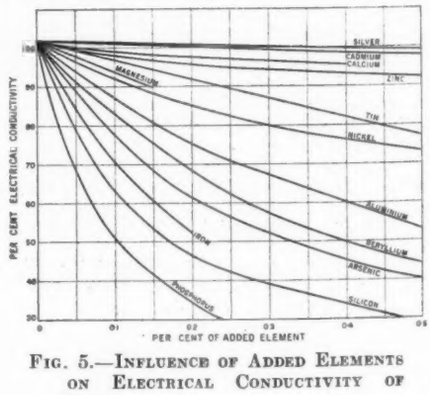


Fig. 5.—Influence of Added Elements on Electrical Conductivity of Copper.

express preference for copper containing 1 per cent. of tin and about 0.05 per cent. phosphorus, and production practice with this alloy has been described by Blakiston.[8] The conductivity of products made in this alloy is naturally low, frequently falling below 40 per cent., as indicated in Table II, presenting observations on various specimens; the conductivity of ordinary commercial phosphorus-deoxidised copper is frequently very little better.

Hence, for conductivity applications where an electrical conductivity value of 80 per cent. might be regarded as the minimum specification

figure, such materials are not allowable. With care in melting practice so that the oxygen content of the metal prior to deoxidation is maintained at a constant figure, it is possible to deoxidise copper with phosphorus so that less than 0.01 per cent. of phosphorus remains in the final product; this amount effects a reduction of about 10 per cent. in conductivity. Naturally, this technique calls for considerable skill and experience and, indeed, the whole subject of copper casting can be said to be one requiring continual practice with more or less constant materials and products under accurately controlled conditions.

Cadmium in amounts of the order of 0.5 to 1 per cent. is frequently used in conjunction with approximately 0.01 per cent. of phosphorus; likewise 1 per cent. of zinc is sometimes used in conjunction with minimum quantities of phosphorus. Both of these elements are very mild deoxidants, but there seems little doubt that they are helpful in obtaining satisfactory castings, probably due to assistance in gas removal and the fact that the zinc and cadmium vapours given off from the stream of molten metal as it is being poured have a protective influence against oxygen pick-up at this stage; in addition the cadmium and zinc permit of greater control over the phosphorus content. However, it might be noted that a 1 per cent. cadmium-copper alloy is not regarded as an easy material to cast in a copper refinery.

Aluminium and magnesium are undoubtedly excellent deoxidants for copper, but the oxidation products are not readily removed and tend to make the molten metal sluggish; in addition, with excess quantities present, there are casting difficulties on account of the oxide films formed on the stream of metal as it is poured. Consequently these deoxidants are not generally employed for these particular products, although Vickers[9] has recorded satisfactory results when using 0.025 per cent. magnesium in conjunction with 0.05 per cent. chromium.

Beryllium presents very similar characteristics to aluminium and magnesium; its suggestion for deoxidation purposes followed from the wide research of beryllium alloys by Masing and colleagues.[10] Results attending the use of beryllium in the production of wrought deoxidised copper have been given by Schumacher and Ellis,[11] who found that a residual amount of 0.05 per cent. reduced the conductivity by 10 per cent. Beryllium is of much more interest in the production of alloys of superior mechanical properties than it is as a deoxidant.

In 1931 lithium was suggested as a deoxidant for copper by two independent groups,[12 13] and as it seems to possess practically all the attributes required of a deoxidant, it would undoubtedly be used to a greater extent if its cost was not so great. To conserve the quantities of lithium required it is usual to employ a calcium-lithium alloy, and as extremely small quantities only are essential, deoxidation is not entirely a prohibitively expensive matter. The recommended addition of 50:50 lithium-calcium alloy is 0.025 per cent., and this has a negligible effect on conductivity; it might, however, be noted that with the addition of excess quantities of lithium, say of the order of 0.08 per cent., a reaction with oxides present in refractories may occur, thus resulting in inferior conductivity of the metal. According to Schumacher and Ellis,[11] alloys made in fused-silica crucibles and alundum-lined crucibles were contaminated with silicon and aluminium, so that the conductivities of hard drawn wires were below 80 per cent. Other experience with lithium has been recorded by Masing and Haase,[10] Schumacher, Ellis and Eckel,[14] Burkhardt and Sachs,[15] and Osborg.[16 17] In addition to its deoxidation features, lithium can also remove hydrogen by chemical reaction, yielding hydrides and hydroxides if oxygen be present, and in recent times some further attention has been devoted to lithium on this account; one instance is in connection with the degasification of copper-lead alloys for bearings.

Calcium has, from the theoretical point of view, strong claims as a deoxidant, and it is difficult to appreciate why it has not been used to a much greater extent in the production of high-conductivity copper castings. For systematic data on the effect of calcium on conductivity, the publications of Schumacher and colleagues[10 11] and Zickrick[19] should be consulted, as there are considerable discrepancies in the results; according to Schumacher, a residual calcium content of 0.1 per cent. depresses the conductivity of wrought products by less than 3 per cent., but Zickrick reports a much greater adverse effect. A factor tending to deter the use of calcium is its acknowledged tendency to give rise to dross inclusions in the surface of castings.[19]

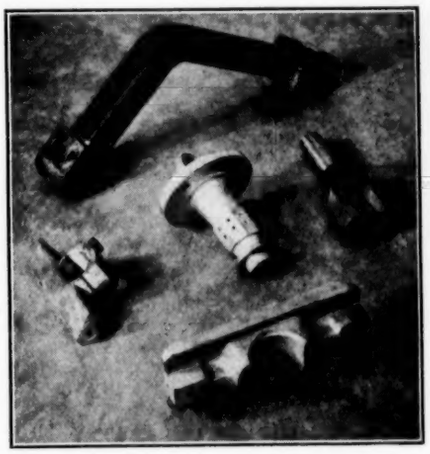
The use of silicon as a deoxidant dates back for a considerable period, and it would seem that the practice of adding this element to copper for electrical castings was in the first place founded on the belief that it did not adversely affect conductivity; however, it is now known that silicon is second only to phosphorus from the point of view of its depression of conductivity. In spite of this, castings having quite good conductivity properties can be produced by means of silicon additions, and a typical production practice was recently described by Phillips[20] who added 0.02 per cent. silicon in the form of a 15 per cent. master alloy; the resultant castings possessed a conductivity approaching 90 per cent., which is a highly satisfactory figure and bears testimony to the care taken at all stages.

Silicon does not impair the fluidity of the molten metal, although it does not confer the same free-running properties as phosphorus additions. There is some indirect evidence that the strength of copper at temperatures just below the melting point is much greater when silicon is present in the metal than when phosphorus has been employed as the deoxidant; this point has only recently arisen from a consideration of the most suitable type of copper for welding.[7] Accepting the validity of this finding, it would seem that the chances of hot-cracking of castings would be less with the use of silicon as a deoxidant, but it is extremely doubtful whether any observations have ever been made on this point.

"Boronised copper" is a term which is frequently encountered, but little information is available concerning the properties of copper-boron alloys; there is, for instance, a dearth of

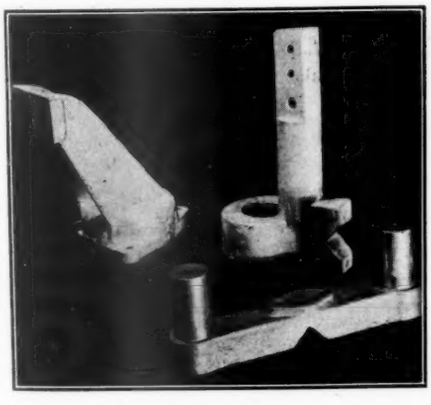
TABLE II.—*Average Properties of Deoxidised Copper Castings.*

Composition.	0.15 per cent. proof stress. Tons per sq. in.	Tensile strength. Tons per sq. in.	Elong. Per cent. on 2 in.	Brinell hardness.	Electrical conductivity. Per cent.	
					Cast.	Wrought (annealed).
1 per cent. Sn, 0.03 per cent. P	2	10	25	40	39	—
0.05 per cent. P	2	10	25	35	60	67
0.9 per cent. Cd, 0.005 per cent. P ..	2	11	30	35	85	94
0.03 per cent. Si	—	—	—	—	75	—
0.02 per cent. Si added (residual amount unknown)	—	—	—	—	90	—



(Courtesy A. Reyrolle & Company, Limited.)

FIG. 7.—CONNECTOR AND CONTACT BLADES AND BLOCKS CAST IN DEOXIDISED COPPER OF 80 PER CENT. MINIMUM CONDUCTIVITY.



(Courtesy Brookhirst Switchgear, Limited.)

FIG. 6.—GROUP OF MACHINED AND SILVER-PLATED COPPER CASTINGS.

TABLE III.—*General Casting Alloys.*

Alloy.	Composition.			Other elements.	Electrical conductivity (cast).	Tensile strength. Tons per sq. in.	Elong. Per cent. on 2 in.	Izod impact strength. Ft.-lbs.	Brinell hardness.
	Cu.	Sn.	Zn.						
Electrical bronze ..	87	7	3	3 Pb	6–12	13–16	14–20	2	50
Admiralty gunmetal	88	10	2	—	10	16–20	8–25	6	65
High-quality brass ..	75	—	25	—	20–25	16–18	40	40	45
General brass ..	60	—	37	2 Pb and up to 1 impurities	14	12–20	15–25	10	50
Manganese bronze ..	58–65	—	rem.	Up to 3 Al, 2 Mn, 2 Fe	15–20	30–40	20	20	100–150
Brass (die-cast) ..	60	—	40	—	25	25	45	30	85
Aluminium-bronze (die-cast) ..	88	—	—	9 Al, 3 Fe ..	10–15	38	40	30	130
Aluminium bronze ..	80	—	—	10 Al, up to 10 Fe, Mn and Ni	6–12	40–47	15–20	20	175–240

information on their conductivity properties. Both calcium-boride and boron-carbide have been advocated as deoxidant additions, and results have been reported by Zickrick.[19 21] A feature of the practice with boron-carbide is that, owing to the stability of this compound, it is necessary to heat the copper to at least 1,300 deg. C.; such a practice must tend to give excessive absorption of hydrogen, and is consequently open to theoretical objections.

Properties of Deoxidised Copper Castings

It is possible to add but little information to that already outlined regarding electrical properties of cast products, and indeed the general run of results should by now be appreciated. As is the case with other properties, such as tensile strength, production technique has an enormous influence; it is possible to envisage variations between about 75 and 90 per cent. conductivity in products of a given nominal composition according to their density and production history, while the same composition in the wrought state might even show 95 per cent. conductivity.

However, it has been effectively proved by many firms that the electrical conductivity of castings may be held within limits of 85 to 90 per cent., but this calls for extremely close control at all stages. The strength and hardness of copper castings are inevitably rather unimposing, as will be apparent from the few figures given in Table II.

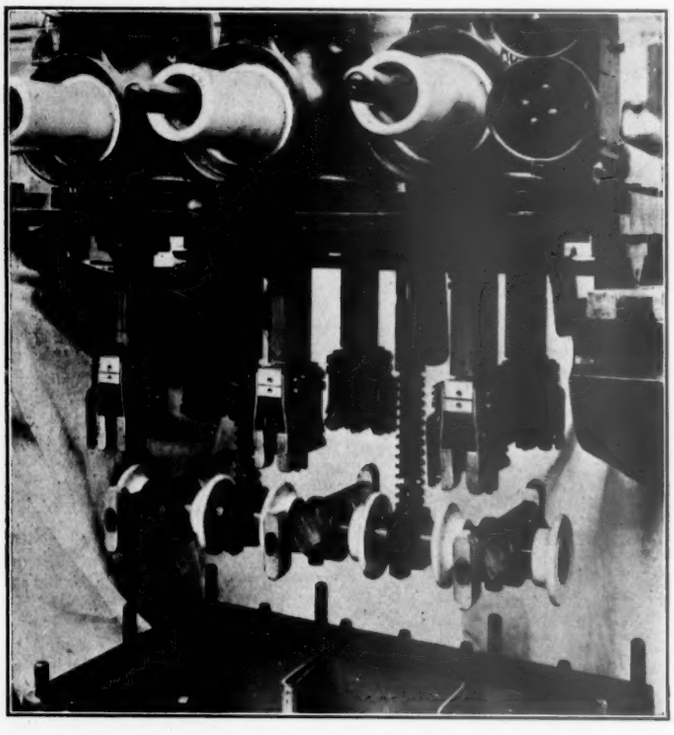
Parts cast in deoxidised copper of 80 per cent. minimum conductivity are illustrated in Figs. 6 and 7, while Figs. 8 and 9 show applications of such castings in switchgear. The three castings shown in Fig. 6 are used for circuit-breaker parts, while of those shown in Fig. 7 the casting at the back is a connector, the other four being contact blocks and blades. Fig. 8 shows a circuit breaker (with oil tank removed) which incorporates cast copper contact blades of the type shown to the left in Fig. 7. Fig. 9 shows a high-voltage circuit breaker (also with the oil tank removed); the cross-arms carrying the contacts are copper castings.

PART 3.—COMMERCIAL COPPER-RICH CASTING ALLOYS

Owing chiefly to their low hardness and strength, together with the fact that such machining processes as tapping and screw threading can only be accomplished with some difficulty, copper castings have conventionally been used by the electrical industries only in essential applications. For most conductivity parts, especially those subjected to mechanical stress or wear, it has been customary to use castings of comparatively heavy cross-section, made in copper alloys of much inferior conductivity but possessing such other desirable attributes as greater strength and ease of machining. It will be shown in Part 4 how new alloys have been developed to meet conductivity and strength requirements, and the purpose of the present section is to summarise the properties of the general copper alloys which in the form of castings find quite extensive applications for electrical purposes.

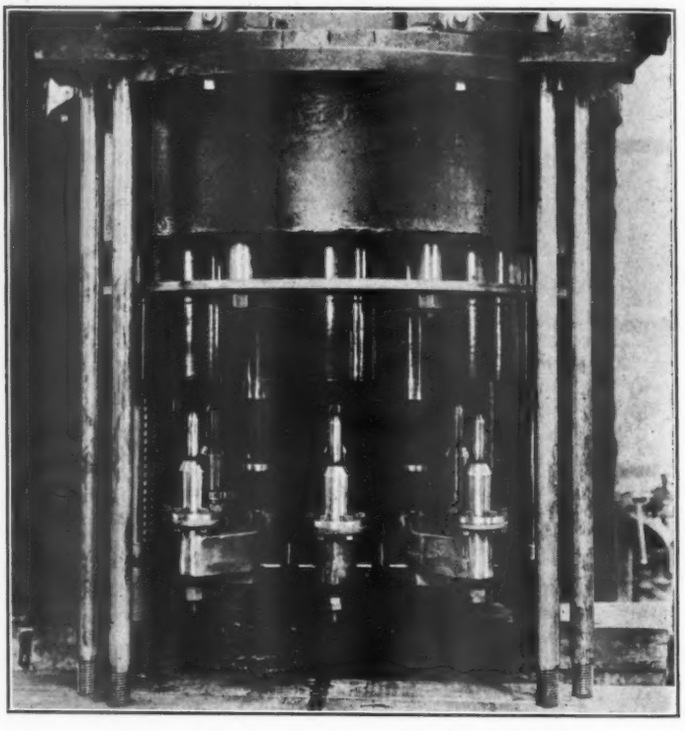
Most of these alloys are of a bronze basis, although in some cases brasses and aluminium bronzes are also employed, the former in sand-cast, die-cast and wrought forms and the latter notably as die-castings. The standard bronze alloy used for electrical castings has a composition of 87 per cent. copper, 7 per cent. tin, 3 per cent. zinc, and 3 per cent. lead, and is known as "electrical bronze"; the lead content ensures good machinability but it impairs strength and ductility, and, under impact stresses, the alloy is particularly weak. Consequently for highly stressed cast parts Admiralty gunmetal (88 per cent. copper, 10 per cent. tin, 2 per cent. zinc) is often specified. Properties of these materials are summarised in Table III, and this shows the extent of impairment of conductivity due to the presence of tin and other alloying elements. Also in this Table are typical properties for other copper-base alloys which are commonly used as castings.

Of these other alloys, brasses are of most importance, and it seems to be overlooked by many electrical engineers that they possess better conductivity properties than do the bronzes. The resistance to wear may, however, not always be as satisfactory, as their "bearing properties" are not so good. Brasses used for casting purposes vary considerably in composition and in purity, and there is little uniformity in the specifications of different users. Sand castings may be made from any brass with a copper content between about 55 and 80 per cent. Recognition might be given to a high-quality brass containing about 75 per cent. copper and 25 per cent. zinc, a common quality brass containing about 60 per cent. copper, 2 per cent. of lead (which improves machining properties), balance zinc, and the group of high-tensile strength brasses (manganese bronzes). In the case of the latter group, particular care should be exercised over the alloy composition if tinning or soldering is to be performed, because the alloys possessing a beta structure are prone to fail by intercrystalline penetration of the tin or solder.



(Courtesy A. Reyrolle & Company, Limited.)

Fig. 8.—Circuit Breaker, showing Use of Cast Copper Contact Blades.



(Courtesy Brookhirst Switchgear, Limited.)

Fig. 9.—High-voltage Circuit Breaker, the Cross-arms of which are High-Conductivity Copper Castings.

(To be continued.)

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Pitting Corrosion of Cast-Iron and Steel Pipes*

By Dr.-Ing. LUDVIK OLŠANSKÝ (Brno)

Introduction

After considering the question, which of the two kinds of pipes is the more durable and therefore the more economical when laying gas mains in localities where mechanical strength is of minor import, the author reached the conclusion that it is neither necessary nor equitable to seek a numerical postulation of the time before perforation of the pipes occurs. On the contrary, it is preferable and more advantageous to determine the relative time in which such pipes would perforate through pitting, under the condition that both types are placed in the ground the same time; under identical circumstances and simultaneously in the same position, and carrying prearranged and frequently occurring defective spots in the protective coating and the insulation, largely set up through mechanical influences.

In other words, the correct determination of the relation of times in which these pipes would be perforated through pitting must be so

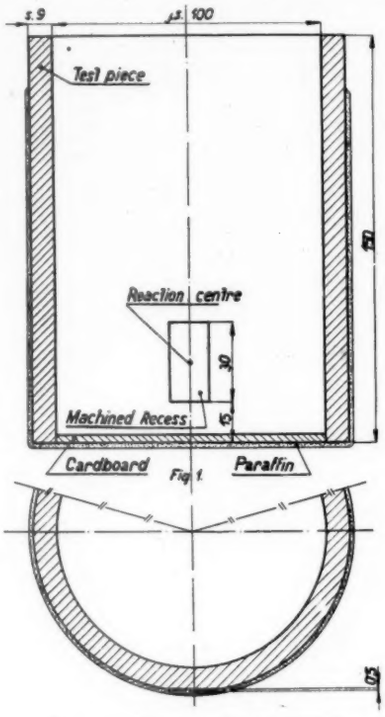

FIG. 1.—TESTING ARRANGEMENTS.

carried out that the corroding action on the outer and the inner surface of the two types would take place under definitely comparative conditions, *i.e.*:—

(1) Identical pressure; temperature; concentration of chemical reagent; quantity of this reagent acting on a given surface of equal size, representing theoretically in the hypothetical case a point. Such conditions cannot be obtained except in a laboratory.

(2) The material examined must be in the state in which it would be after the protective coating or insulation has been destroyed. Every other experimental method, especially the machining of the surface, will give wrong results in the evaluation of pipe material, as will be seen from what follows.

Moreover, it is essential that, when examining the depth of the corrosion, the material lying immediately against the place attacked must be maintained to conform with the original wall thickness dimension, so as to be able to study metallographically the eventual divergences in the depth of the corrosion which might be pursued only in the case of corrosion at one spot.

By insisting upon the above-mentioned comparative conditions, and securing the correct proportion of times in which the material of the pipe had been perforated by pitting, it is possible to state which pipes are the more durable and therefore the more economical. Should, for instance, a pipe line last for x years, then in the same locality, under the same condition, another pipe line would last for px years, where p is the number indicating how many times one pipe is more resistant, and therefore more enduring than another. The cause of the destruction of cast iron and steel pipes has been studied by the author on sections of pipes which had not been machined, *i.e.*, complying strictly to the necessary comparative conditions, and later on machined sections of pipes. For these tests a 5 per cent. solution of HNO_3 was used and the results derived therefrom on sections of both cast-iron and steel unmachined pipes were given before the Paris International Foundry Congress in 1937 under the heading, "Une Étude sur les Effets Corrosifs sur les Tubes en Fonte et en Acier."

In what follows the author proposes to detail the methods used for studying the perforation by pitting of machined sections of cast-iron and steel pipes, as well as a comparison of the results obtained under similar and comparative conditions with those obtained when working with unmachined pipe sections under identical conditions.

Experimental Work

The temperature of the laboratory was controlled during all tests at about 20 deg. C. For the tests sections of cast-iron pipes, marked TH_1 to TH_4, having an inner diameter of 4 in. and 6 in. long, were used, together with sections of steel pipes having similar dimensions which were marked th_1 to th_4. Into these pipe sections, at a distance of 15 mm. from the base, a recess 30 mm. long and 0.5 mm. deep was cut. It was as is shown in Fig. 1.

In order to ensure that the corroding agent will produce a pit only at the required spot, it was necessary to carry out a further and now well-known preparation of the sample. A cardboard sheet was placed in the base of the pipe section, and the test-pieces so prepared were dipped with the cardboard base bottom-most into molten paraffin so that it reached the upper edge in order to obtain, after removing it and allowing it to cool, a good overall protective coating, adhering well to the surface. Once again, as the corroding agent, a 5 per cent. solution of nitric acid was used. Glass containers having a diameter of 10 in. and 5 in. high were used. Before starting a standard quantity of the acid, *i.e.*, 3.5 litres, was poured into each of these containers.

To measure the corrosion effect, a simple arrangement, shown in Fig. 1 of the Paris Congress Paper, was used, which made it possible to measure the pits produced by the corrosion in three axes ranged vertically to each other. This measuring arrangement consisted in principle of a cross-support, the shifting of which in two horizontal axes, vertical to each other, was provided with a millimetric scale. This cross-support carried an indicator to measure the depth in the third axis vertical to the two preceding ones. The cross-support was fixed to a support provided with an attachment to hold the parts of the pipes to be measured.

Testing Procedure

From the test-pieces so prepared, the protective coating was destroyed by puncturing it in the same place as near the middle of the surface to be tested as possible, so as to bring

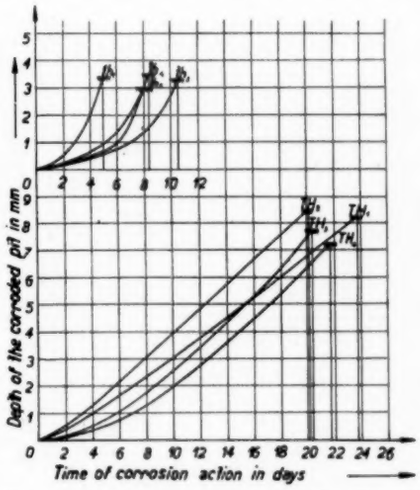

FIG. 2.—DEPTH OF CORROSION RELATED TO PERIOD OF ATTACK.

the uncovered area beneath the surface of the liquid agent for the duration of the test. The two test-pieces to be compared were invariably placed into the containers filled with the acid, the cardboard bottom-most, for a time interval of 5 mins. In this series the action of the reagent was periodically interrupted for two days, allowing sufficient time to measure the shape of the pits produced by the action of the acid. During the test, the temperature (*circa* 20 deg. C.) was constantly measured.

A graph showing a numerical indication is given in Fig. 2. These tests were repeated on sections of the cast-iron pipe TH_1 and the steel pipe th_1, the depth of the cylindrical recess being increased to 1 mm. The results obtained are illustrated in Fig. 3.

In order to be able to compare the progress of the destruction of the material of machined

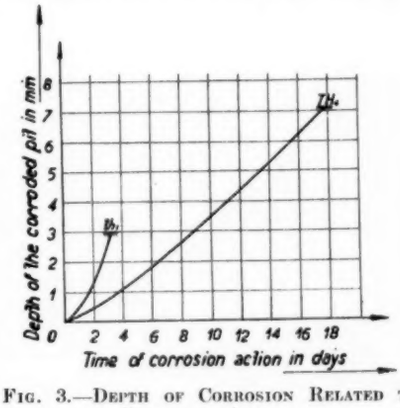

FIG. 3.—DEPTH OF CORROSION RELATED TO PERIOD OF ATTACK.

and unmachined pipes exposed to the corroding agent under exactly similar conditions, it has been deemed necessary to construct the diagram in Fig. 4 on the basis of numerical records. In the diagrams (Figs. 2 to 4) the time in days has been set out on the horizontal axis, whilst on the vertical one the respective maximum depths in mm. of the pits produced by the action of the 5 per cent. HNO_3 at an average temperature of 20 deg. C are given. The thickness of the walls of the pipes is limited by a

* Paper presented to the International Foundry Congress held in London and organised by the Institute of British Foundrymen.

horizontal axis and lines parallel to it by cross-hatching.

From a study of the curves of Fig. 2, showing the progress of the pitting corrosion in depths in both types of pipes at places which have been machined, it is evident that these curves have nearly the same shape and the same trend as the curves in Fig. 4, showing the magnitude under similar conditions for the same materials extending from 0.5 mm. and initiating a progressive corrosion.

Similarly, from a study of the curves of Fig. 3 showing the progress of pitting in depths for both types of pipes at places which were machined to a depth of 1 mm., it is shown that these curves again have practically the same shape and the same trend as the curves in Fig. 4, showing the progress of pitting of the same materials, but this time extending from 1 mm.

Fig. 4.—Depth of Corrosion Related to Period of Attack.

Conclusions

From the above comparisons and tests the following conclusions can be drawn:—

(1) The widely-held opinion as to the importance of the as-cast skin for increasing the resistance of cast-iron pipes to corrosion set up by the influence of corroding media is a sound one.

(2) The scale (magnetic oxide) formed during rolling has the same importance for increasing the resistance of steel pipes to corrosion as the as-cast skin in the case of cast-iron pipes.

(3) The outer layer of the material of pipes situated immediately beneath the as-cast skin, or beneath the scale, is much more resistant than the internal layers.

(4) The as-cast skin or the scale and the layers of the surface situated directly behind them at those places which are opposite to points where the corrosion began, have no influence on the resistance to corrosion.

(5) It is only desirable to make a comparative test on cast-iron or steel pipes with an unmachined surface, *i.e.*, as they are used for laying gas mains.

(6) It is impossible to evaluate the resistance of cast-iron and steel pipes to corrosion on the basis of machined cylinders as has been indicated by the author under the signature H. B.* for, by machining, the qualities of both the casting and the steel are completely changed with regard to the influence of corroding agents.

Composition

The chemical composition of the cast-iron pipe and plugs used in these tests was:—T.C. 3.67 to 3.71; C.C. 0.88 to 0.97; Si, 1.64 to 1.83; Mn, 0.60; S, 0.075 to 0.08, and P, 0.19 to 0.45 per cent.

The composition of the steel pipes and plugs was:—C, 0.38; Mn, 0.73 to 0.8, and P, 0.03 to 0.031 per cent.

The author considers it his duty to express his thanks to Dr. Mont. Ing. Fr. Píšek, Professor at the Czech Technical University of Brno, for his great interest and kind help during the study of this subject.

In the absence of the author, Dr.-Ing. Olšanský's Paper was presented to the Congress by Dr. A. B. Everest, who, having introduced it, said that although it might be unusual for the introducer of a Paper to comment on it, there were one or two points on which he would like to speak.

The author, Dr. Everest observed, had evolved a test for the corrosion resistance of pipes, but he felt that a test of this type must be treated with considerable caution. In his experience, the failure of cast-iron or steel pipes was generally due to causes which could not be taken into account in a test of the type described by the author. Failure in most cases was due to some abnormal condition, such as a local defect in the pipe or in its protective coatings, or very often was due to aggravated electrolytic corrosion caused by stray electric currents. It was well known, for instance, that in London a great deal of trouble with gas and water mains was due to stray currents from tramways and similar sources.

These factors were generally more potent than straight corrosion, and this must be borne in mind in considering the Paper. On the other hand, the Paper did put forward a test of interest in comparing the absolute corrosion resistance of different materials, and the Congress was indebted to the author in this respect.

Stewarts and Lloyds—Stanton Merger

The stockholders of Stewarts and Lloyds, Limited, have received a circular setting forth the terms and other conditions by which, as indicated in our issue of July 20, it is proposed that Stewarts and Lloyds acquire the whole of the issued capital of The Stanton Ironworks Company, Limited. The directors state that "the price to be paid for the shares of The Stanton Ironworks Company, Limited, is fair and reasonable, having regard to the past history, assets, and resources of that Company."

An extraordinary general meeting of the Company will be held on September 21 to pass resolutions increasing the capital of the Company for the purpose of acquiring the issued share capital of the Stanton Company and to approve the terms of the provisional agreement.

Hot Tinning of Cast Iron

An article bearing the heading "Hot Tinning," printed in "Tin and Its Uses," No. 2, deals with the tinning of cast iron in the following terms.

Cast iron cannot usually be tinned even after the usual treatments have been carefully applied, since it contains minute flakes of graphite to which the molten tin will not adhere. It is generally prepared by sandblasting or tumbling to remove scale and sand, followed by brief pickling, and is then electroplated with iron to provide a basis for the tin.

The prepared articles are dipped into a flux solution before being immersed in the bath of molten tin. The most usual basis for fluxes is zinc chloride, and this may be used alone as a strong aqueous solution. It is beneficial, however, to add some 10 to 20 per cent. of ammonium chloride, as this makes the flux more fluid when molten (in which condition it does its work). The surface of the molten tin is covered with a layer of the same flux, through which the articles are immersed, and which effectively removes any trace of oxide before the article reaches the tin.

For high-class work, particularly in the case of iron and steel articles, two tinning baths are employed, the articles being dipped in the second immediately after withdrawal from the first. In this case quite a thick layer of flux is kept on the first bath, since it is unimportant if a little remains adhering to the article when it is withdrawn, and the second bath as its tin is less contaminated with dissolved iron gives a smoother and brighter coating. The second tinning bath, when used, should be covered with a small amount of tallow, and must be kept reasonably cool or the coating will oxidise to a yellowish colour on withdrawal.

If only one bath is employed less flux is used, so that it may be skimmed aside and the article taken out through a clean surface.

Publication Received

Lead-Lined Bronze Bearings. English edition translated from "Bleibronzen als Lagerwerkstoffe," and published by the Copper Development Association, Thames House, Millbank, London, S.W.1.

This book was first published in German by the Deutsches Kupfer-Institut, of Berlin, and is of outstanding interest, because it is in Germany where the greatest interest has been taken in processes which replace imported metals—and tin is one of them—by those available nationally. As lead enters into this category, it was only natural that attention should be turned to lead bronze bearings. Rumours were current during the last war that bearings made from limestone soaked in oil were used! The book runs to about fifty pages, and in fourteen sections covers all phases essential to a proper understanding of the subject. Copies of the book can be obtained free of charge from the Association by those making application on firms' headed notepaper or otherwise giving evidence of responsible status or genuine interest. On behalf of our readers we thank the publishers for their very generous offer.

New Admiralty Contracts

The Admiralty have placed orders with shipbuilding firms in Scotland and England for 52 vessels of the "minor warship" classes. These comprise boom-defence vessels, trawlers, and patrol vessels of the whale-catcher type. The group consists of six boom-defence vessels, 20 trawlers, and 26 patrol vessels, and of the total number 31 are to be built in Scotland and 21 in England.

* Strojnický Obzor, 1936, p. 45.

Developments in Steel Foundry Technique

DISCUSSION AT CONGRESS SESSION

The final technical session of the recent International Foundry Congress in London was held jointly with members of the Iron and Steel Institute, and was devoted to the discussion of Papers dealing with steel foundry practice. Mr. W. B. Lake, J.P. (President of the Congress), presided; he was accompanied on the platform by Dr. Guido Vanzetti (President of the International Committee of Foundry Technical Associations), Mr. Headlam Morley (Secretary of the Iron and Steel Institute), Dr. C. H. Desch, F.R.S. (President of the Institute of Metals and a Vice-President of the Iron and Steel Institute), and the authors of the Papers to be presented.

The PRESIDENT welcomed the members of the Iron and Steel Institute, and expressed indebtedness to them for joining in the discussion.

MR. W. J. DAWSON responded on behalf of the Iron and Steel Institute. The members of the Institute of British Foundrymen, he said, were reciprocating a similar compliment paid to them on the occasion of the presentation of the last Report of the Research Committee on Steel Castings.

STEEL FOUNDRY RESEARCH

The first Paper to be presented was "The Development and Organisation of Steel Foundry Research" (see JOURNAL for August 3 and 10).

The author, MR. W. J. DAWSON, presenting the Paper, said that, in connection with that section outlining foreign research activities, he had subsequently received a communication from Dr. Vanzetti, who had stated that in Italy there was an institute specially engaged in steel foundry research, and that the National Council in Rome was engaged on the same subject. Whilst at present there was no centre of organisation for research on foundry matters there, it was proposed to inaugurate one very shortly. Education in foundry science, commented Mr. Dawson, appeared to be very adequately dealt with in Italy. He added that he wished to apologise for not having mentioned the useful work carried out by the Technical Committee of the Institute of British Foundrymen, more particularly the Sands Sub-Committee and the Steel Castings Sub-Committee. He wished to ventilate, he said, the desirability of closer and more intimate association of ideas than had been effected in the past between the co-operative bodies engaged in research work.

The Steel Castings Reports

The PRESIDENT (Mr. W. B. Lake), commending the Paper, mentioned the hope expressed by Mr. Dawson that it would lead to an exchange of ideas on the findings put forward by the Steel Castings Research Committee. He hoped sincerely that that would be the case; but he was rather doubtful, because the conclusions had been arrived at after such careful study that he did not think many people would venture to criticise it.

MR. C. D. POLLARD (Derby), after paying tribute to Mr. Dawson and his colleagues for their valuable work as set out in the Report, said that he and those who were engaged on production in the works were doing their utmost to put into practice the investigations enumerated in the Report. At the same time, however, the scientists were doing their best to help the works executives to understand the more abstruse matters without the aid of such research work as that which Mr. Dawson and his committees were carrying out.

MR. F. N. LLOYD (Wednesbury), referring to the work of the Foundry Practice Sub-Committee mentioned in the Paper, said that it was formed with the very idea of correlating foundry practice in various works. The Sub-Committee had been in existence only about six months, but during that time it had found that results were not going to be obtained quickly. The members of the Sub-Committee had pooled their ideas, and then by experiments conducted in their various firms they tried to prove or disprove their ideas and to reach agreement upon those fundamental theories upon which all their ideas must be built. They had progressed a certain distance, and had been working on the production of steel castings under various heads and under closely controlled conditions of casting, and they hoped to be able to report on that matter within a short time. He mentioned the matter to show how they were tackling the very awkward problem submitted to them, and to show that the work was being done by people actively engaged in the foundry industry.

DRY SAND PRACTICE FOR STEEL CASTINGS

Mr. F. W. Rowe's Paper on "Radiography in Iron and Steel Founding," which was then presented and discussed, has already been printed in our columns, together with the discussion on it. It was followed by the communication from Dr. C. J. Dadswell and Mr. T. R. Walker on "Notes on Dry-Sand Practice for Steel Castings," which we published last week.

The discussion was opened by MR. V. C. FAULKNER (Past-President, Institute of British Foundrymen), who asked whether the steel-foundry industry had carried out any experiments in connection with the metal spraying of cores or mould surfaces with aluminium. It had been done successfully but to a very limited extent in ironfoundry practice, but he had not heard of experiments in connection with steel founding. He wondered whether it was of value, or whether the authors would regard it as merely a waste of time.

Influence of Elevated Temperatures on Sands

DR. J. G. A. SKERL, having commented on the great practical importance of the Paper to the steelfounder, said that graphs in Figs. 2 and 3 confirmed some work he had carried out for the British Cast Iron Research Association some years ago. In that work the cold compressive strengths of a range of sands after heating to certain temperatures were determined. It was found, for example, that the red sands of the Midlands of this country, which were somewhat comparable to the red sands of Belgium as regards part of their chemical composition, showed, after heating to about 250 deg. C., a progressive decline in strength at higher temperatures, whereas the Scottish rock type of moulding sand, which was similar to the Millstone Grit series from the Sheffield area, showed a gradual increase of strength as the temperature of drying became greater. The Erith sands and Pickering sands gave intermediate results.

The two graphs referred to raised the question as to what was required in a moulding sand. One could have two types of sand, one of which had decreasing strength with increase of temperature, and the other increasing or retaining its strength. For some jobs, such as the production of a plain cylinder, a sand which retained its strength at high temperature must be of great value, especially as regards running. But for castings with ribs and flanges, etc., such a sand would be disadvantageous, because between the ribs or flanges a pressure would be developed in the sand due to the expansion, which would go against the contraction of the metal and so increase the liability to burn on. Therefore, it was necessary to choose sands to suit the particular job in hand.

For the general purposes of the steel foundry, the Belgian type of sand was preferable, because it lost strength at high temperature; and it was only for heavy castings that materials such as compo had to be used, which retained or increased strength at high temperatures.

He was very definitely of the opinion that the stoves which were referred to in the Paper as core stoves were not core stoves at all, but were merely annealing stoves. The difference of temperature throughout the stoves was enormous, and one must feel that if some moulds were sufficiently dried, some must be under-dried and some must be definitely burned.

With regard to mould paints, he asked whether they were applied before or after the drying of the moulds. In the iron founding industry it was found that when certain sands were used one could coat the moulds in the green condition, whereas that could not be done with other sands, and he asked whether that was the case also in the steel founding industry.

Moisture Removal from Stoves

MR. M. BROWN (Hadfields, Limited) said that the drying of moulds and cores was essentially a low-temperature furnace process. In the heat-treatment of alloy steel, such as tempering, uniformity of results was only attainable by circulating the atmosphere in the furnace to avoid the stratification caused by natural convection when the atmosphere was not disturbed. He felt that this principle could be applied with advantage to mould drying.

Another problem which did not arise in the heat-treatment of alloy steels, but was very important in mould drying, was the removal of moisture, and if one could get an instrument which would record automatically the degree of saturation of the exhaust gases the industry would be in a better position to control the drying process and could possibly speed it up. He wondered whether the authors of the Paper had considered these two aspects of the problem.

He also asked whether the sand used for the cores was the same as that used for the moulds. Fig. 11 gave a very good illustration of the phenomena met with in steel casting practice, that is, the difference in "burning-on" between a concave and a convex surface.

Ayrshire Chamotte

MR. J. E. O. LITTLE (Glenfield & Kennedy), referring to chamotte, asked exactly what was meant by the "calcined" bauxitic clay which was obtained in Ayrshire, for his foundry was in the district. In Ayrshire there was a quantity of surface clay of extremely low refractoriness; it was used to a certain extent in foundries in that district as a bonding clay for some of the wet loam for iron castings, and he wondered whether the bauxitic clay would be useful. Having made inquiries of various refractory suppliers, he had obtained very varying replies or widely differing definitions of "chamotte." Apparently most of them referred to it as being the crushed-up rejects or scraps of bricks which were put back into the mixture as a grog when making a fresh brick. He asked whether the contained about 40 per cent. alumina and tent, because most of the materials in the district contained about 40 per cent. alumina, and whether it was supplied by just one particular firm.

MR. J. DESCHAMPS (Kryn & Lahy, Limited) also asked for further information as to the theory concerning the use of chamotte, which was said to be a calcined bauxitic or siliceous clay. He asked what happened in the calcination. Was it aimed to effect a modification in the allotropic state of the silica?

Commenting upon a reference in the Paper to the drying of chamotte at a temperature of about 700 deg. C., he said that that seemed to be a very much higher temperature than one

dare employ in making sand moulds, and he wondered whether the figure was a mistake. If it were not a mistake, he asked what reaction occurred at that temperature.

MR. A. P. RILEY (Sheffield) asked whether the authors had found that the type of milling and the milling time employed for their sands made any appreciable difference to the results. Also, he asked whether the backing sand was varied according to the facing sand used. Commenting upon a remark by Mr. Walker that a mould should be closed and cast as soon as possible after drying, presumably while still warm, he asked whether that remark applied to oil-bonded sands.

AUTHORS' REPLIES

DR. DADSWELL, replying to Mr. Faulkner's question concerning the possibility of metal-spraying the cores or moulds in the steel foundry, said that they had not attempted it. They had thought of metal-spraying, but more particularly in connection with the protection of patterns, especially when used with the Sandslinger. He did not think that metal-spraying would have an application in steel moulding, because none of the metals which could be sprayed had a melting point sufficiently high to be of any use. Even if the core or mould were sprayed to give a layer of steel, he did not think the thickness of that layer would be of any use in contact with the molten steel.

Drying Stove Details

Dealing with Dr. Skerl's remarks concerning the drying stoves, he said that the stoves themselves had been in use for some years with a poor form of firing. The period of drying was at that time too long and the quality of the drying was bad. They were therefore modernised by installing new fireboxes and air-mixing chambers. The view in elevation of the fire side of the drying stove shown in Fig. 4 was a little misleading, and probably would lead Dr. Skerl to think that they looked rather like annealing stoves. Actually, the ports did not enter into the firebox, but into a form of mixing chamber. The products of combustion passed from the firebox into the mixing chamber, where dilution air was added, *i.e.*, a third supply of air, so that all the secondary air was not necessarily added in the firebox. The third supply of air was added in the mixing chamber to reduce the temperature of the products of combustion to the temperature of drying. The investigation was undertaken to find the best distribution of the ports. Having tried the stove for a while, it had been possible to improve the distribution by blocking up some of the ports and forcing the gas to take a certain course round the stove. The results were included in the Paper in order to show the necessity for studying the behaviour of stoves. It was a fairly easy investigation, for all they had done was to make a number of holes through the stove doors and to insert pyrometers.

The results of the tests on the dry strength of sands after different standing periods showed in quite a gratifying manner how laboratory experiment could definitely prove something which one had learned by practice and which one had not been able to show by scientific means. It did not always happen that way, but in that particular case it did, and that was why he regarded the results obtained as being so very interesting.

Paint Application

Paints were applied to green moulds before drying; but they were only applied to oil-sand cores when the cores were warm and dry. Certain compo moulds and cores received a further coat of paint when coming out of the stove, *i.e.*, whilst still hot; but the general practice was to paint moulds, sand cores and compo cores when they were green.

The remarks of Mr. Brown concerning the similarity between heat-treatment furnaces having re-circulation and a good drying stove were interesting. He believed the success of the continuous core-drying stove was partly due to the fact that one obtained good circulation, as the cores came out very much more uniformly dried than they often did from the ordinary batch type of stove.

For producing the casting shown in Figs. 9 and 10 the core material used was different from the mould material. In both cases synthetic sands were used, but the core contained a certain amount of core binder. The casting in Fig. 11 was slightly thicker than that in Figs. 9 and 10.

Use of Chamotte

The chamotte from Ayrshire was received from one supplier. He believed that a calcined clay such as that, of from 40 to 45 per cent. alumina, could be sufficiently refractory from the point of view of making a synthetic mixture, but in its raw state, used as a bonding material, it might not be sufficiently refractory. He had not used the Ayrshire clay as a bonding medium, but had used one of the Derbyshire fireclays. The high-alumina clay was used only as a grog, so that the explanation of the word "chamotte" that was given by Mr. Little was more or less correct. It really meant grog, and it was the coarse material which formed the basis of the refractory material. He and his colleagues had adopted the word "chamotte" because they had originally tried the method which might be described as the "Skoda method," using chamotte only, plus bonding clay. But that was rather expensive and the technique was rather different from the usual, so that it involved training the men; further, the cost of the material was rather high, for it had to be transported from Ayrshire to Sheffield, and in addition calcining was necessary. Therefore, they had used the chamotte clay as an ingredient in the ordinary compo in place of the old crucible pots formerly used. This used to be what might be called a witch's brew, consisting of a bit of everything, but it had since been simplified by using chamotte and old firebricks, etc.

Dealing with the reference by Mr. Riley to the type and time of milling, Dr. Dadswell said that both in the case of compo and of synthetic sand, those factors made a difference. In compo one was dealing with coarse materials and had to spread the clay around coarse grains, so that a heavier type of milling was necessary than for synthetic sands.

The type of backing sand was not varied in dry-sand practice over a certain weight. When using compo or synthetic facing for the larger castings, a common backing sand could be used. Oil-sand moulds should not be cast warm. The remarks in the Paper with regard to closing the mould as soon as possible after drying had related to clay-bonded sands. Indeed, the whole of the Paper really referred to clay-bonded sands, except for a brief reference to oil-bonded cores.

Aluminium-Sprayed Moulds

MR. WALKER, replying to Mr. Faulkner, said he knew of one steel foundry which had tried spraying cores with aluminium, the purpose being to supply a little extra aluminium to the steel and ensure that the steel in the mould was killed. The process had subsequently been abandoned.

Regarding Dr. Skerl's remarks, he agreed that the curves in Figs. 2 and 3, showing the cold compressive strength of sands after being heated to certain temperatures, confirmed the results obtained by Dr. Skerl in his work for the British Cast Iron Research Association. Some of the experiments carried out by Dr. Dadswell and himself, however, had been made on British materials not hitherto used for steel-foundry work, as they were investigating the possibility of finding new British materials for this purpose. So far they had not found any new materials with exceptionally good properties, and, generally speaking, the results were similar to those obtained by Dr. Skerl some years ago.

Replying to Mr. Brown, he said that they had made a large number of experiments in which they had analysed the gases issuing from the drying stoves to determine the moisture content, but so far they had not obtained a recorder for that purpose. He was not sure whether a recorder was on the market which would be entirely suitable for that particular service.

Ayrshire Bauxitic Clays

Discussing Mr. Little's reference to bauxitic clays, Mr. Walker said that there was only one particular type of Ayrshire clay which was suitable for the purpose mentioned, and it could be obtained from more than one manufacturer of refractory materials. Apart from its chemical analysis, an important property of the material was the manner in which it broke up on crushing after calcining. The particles so obtained should be angular and the size distribution was important if the material were to be successfully used in the steel foundry.

The Ayrshire bauxitic clay referred to was not quite the same as the original Skoda chamotte; it had not exactly the same properties, but it was the nearest approach to the Skoda chamotte that the authors had been able to find in the British Isles. Mr. Deschamps had queried the temperature of 700 deg. C. which was mentioned in the Paper as the temperature to which a mould of chamotte and clay was heated during drying. That temperature had been frequently used at Skoda, and the authors had also used it on more than one occasion in their own foundry. There was no doubt that that temperature, or something very near it, was very suitable for drying the moulds of the Skoda chamotte. For the British material the temperature need not be quite so high, but it should be much higher than was ordinarily found necessary for drying sand moulds. A suitable temperature was a little below 600 deg. C.

Replying to Mr. Riley, Mr. Walker considered it best to allow oil-sand moulds to go cold and then to leave them for 24 hours before filling them with metal. This was because the strength of such moulds increased on cooling right out and for about 24 hours afterwards, whereas in the case of dry-sand moulds the strength fell rapidly as soon as the moulds become cold.

RENAISSANCE OF THE STEEL CASTING

The Paper on "The Renaissance of the Steel Casting and the Rôle of the Metallurgist," by F. A. Melmoth, was introduced by Mr. C. H. Kain in the absence of the author.

The first half of the Paper is reproduced on page 126 *et seq* of this issue.

American Locomotive Frame Castings

MR. T. HENRY TURNER (chief chemist and metallurgist of the London & North Eastern Railway), opening the discussion, said his experience of American steel-foundry work was limited to a short visit to U.S.A. and Canadian foundries in 1926. He regretted that illustrations had not been included in the Paper, as he had been greatly impressed by the amazingly large and complicated steel castings which were tackled in the U.S.A. He quoted as an example the steel casting made in one monobloc to include both the long side members and all cross members of a locomotive frame, and the complicated cylinder casting which might include four cylinders.

That all this could be made in one colossal monobloc was a very remarkable achievement, and it seemed hardly necessary to head the Paper "The Renaissance of the Steel Casting" when American foundries had been able to produce such castings and when such castings were in some cases replacing forgings.

The practice in this country and on the Continent was to build up locomotive frames from forged parts, but it was claimed in the United States that these complicated monobloc frame and cylinder steel castings were more economical to maintain than forged frames for the very heavy locomotives used in that country. Moreover, these cast steel frames had been exported

to Australia and elsewhere. So far as he could judge, the history of castings in the United States was one of constant progress, and he had been interested to note, in every steel foundry which he visited, the use of electric furnaces.

The author's remarks regarding research and metallurgists deserved especial attention. There was a time when trained metallurgists found the iron foundry unattractive in the way described by the author for the steel foundry, but the development of foundries along better engineering lines had made the foundry a less unattractive place than it was, and one might therefore feel confident that when the author stated that the major portion of the rôle of the metallurgist in the advancement of steel-foundry work remained to be played, metallurgists would be found to assist the engineers in such developments, and if X-rays were used in the development of new casting designs and magnetic crack detection was employed in the inspection of the finished castings, there was no reason why engineers should not have greater faith in the steel casting than ever before, even if the specifications were stiffened up appreciably.

MR. R. CHAVY (France), referring to the development of some special steels for crankshafts, said that their composition was very different from that of steels used for forging, the property of fatigue strength being rather more important than tensile strength or elongation.

Potentialities of Plain Carbon Steel

MR. J. DESCHAMPS (Kryn & Lahy) said he would have liked to have asked whether the author was quite satisfied that the potentialities of plain carbon steels for castings had been fully exploited. Was it really necessary to resort to the obvious and easy method of alloying the steel in order to improve it, instead of exercising the necessary care in improving the plain carbon steels? Reference was made in the Paper to an extraordinarily good result obtained with a fully heat-treated steel casting, showing a maximum tensile stress of 40 tons per sq. in., yield point approximately 27 tons per sq. in. (which was about 70 per cent. of the ultimate tensile), elongation 30 per cent., reduction of area 60 per cent., and a Charpy impact figure of 30 ft.-lbs. (the latter figure corresponding with 35 or 40 Izod). Mr. Deschamps urged that such results could be obtained with plain carbon steels, provided they were properly controlled. Why, therefore, should we resort to the relatively expensive method of alloying and heat-treatment, when similar results could be obtained without heat-treatment from properly made carbon steel?

Another question was whether the American steelmakers felt, as some foundrymen did in this country, that the specifications they had to work to were too lenient. Almost anybody could make steels to meet some of the specifications; he was definitely of the opinion that the specifications should be made much more difficult, and that this move would benefit the steel-foundry industry, which was bemoaning the fact that forgings were replacing castings.

Again, he asked whether there were great developments in America in the direction of making composite assemblies of steel castings and welded parts, as, for instance, by welding plates to castings; or, still more interesting, whether there were developments in the direction of replacing intricate steel castings by an assembly of plain steel castings which could be made on production lines by semi-skilled labour and welded together.

Finally, he wondered whether further developments had taken place in America in connection with the application of the hydro-blast to replace shot-blasting.

MR. A. TIPPER commented on the similarity of some of the statements made by Mr. Melmoth, particularly with regard to moulding materials, and by the authors of some other recent Papers, as, for instance, Mr. J. J. Sheehan, in his Paper before the Congress on the subject of core shop control, and by Mr. Hudson in a Paper not very long ago in which he had stressed the importance of the control of grain size. Mr. Melmoth had stressed the importance of obtaining better surfaces on castings, and had pointed out that the moulding material was a very important factor affecting the surface condition. He had also stated that "From the realisation that permeability to rapidly evolved gases is essential in both facing and backing, there has developed an almost general use of sand handling and reclaiming equipment." That was recognised here both as regards iron and steel foundries. The statement that, generally speaking, there was no attempt to remove all fines, presumably meant that, instead of attempting to keep the sand in the right condition in that way, we should select the right type of sand primarily. The work of Sheehan on the fitting-in of grain sizes had an important bearing on that. Another statement which it was important to note was that concerning the selection of a backing sand with a higher permeability and lower bond where one was using separate backing and facing sands. That principle also had proved to be successful when applied to cast iron sands in this country, and he believed it could be regarded as proved for steel also.

GASES IN METALS

The final Paper to be submitted was "The Relationship between the Quality of Iron and Steel Castings and the Nature of the Materials of the Melt," by Dr. Ing. P. Bardenheuer (see our June 22 issue).

MR. T. R. WALKER (English Steel Corporation) remarked that the Paper followed many others which Dr. Bardenheuer had published in the German technical Press concerning the effects of gases, especially hydrogen, in metals and particularly in steel. Dr. Bardenheuer claimed that the effect of hydrogen in steel was always deleterious, and Mr. Walker asked whether it was now established beyond doubt that hydrogen was the real and only cause of hair cracks. There had been a good deal of argument regarding this matter, in which Dr. Bardenheuer had taken a prominent part.

Expressing agreement with Dr. Bardenheuer's remarks concerning the effect of the gases in pig-iron on the properties of the resultant steel, Mr. Walker asked whether he had been able to trace any general relation between the amount of gas in pig-iron, and either the country of origin or the process employed in manufacturing the pig. For example, it was commonly assumed in this country that Swedish pig gave better results when certain types of steel were being manufactured than English pig of similar analysis. Was that attributable to a difference in gas content between the two types of pig? Again, in the manufacture of certain types of iron castings, some makers attached a great deal of importance to the use of cold-blast iron and claimed that it gave improved results. Was that also connected with the gas content of different types of iron?

Case of Ferro-Manganese

Although Dr. Bardenheuer had given the results of the gas content for different alloying materials he had omitted reference to ferro-manganese, which, however, definitely contained gases. If samples of ferro-manganese, of the same grade but manufactured by different makers, were treated with cold water, gases were evolved, the volume of gas from the same weight of ferro-manganese being different for different makes. Presumably this was due to the fact that the different makes of ferro-manganese contained different constituents.

Dr. Bardenheuer had also omitted any reference to the nitrogen content of ferro-alloys; although this was unimportant in most cases, it was of special importance in ferro-chromium. Ferro-chromium containing high contents of nitrogen was being used both in America and Great Britain on account of the effect it had on the mechanical properties and the grain size of the resulting steel, which was commonly high-chromium steel. In that case at any rate it was evident that the effect of gas content in the ferro-alloy was significant in determining the properties of the resultant steel.

Major Difficulties for Ironfounders

DR. BARDENHEUER, dealing with the question as to whether hydrogen caused hair cracks, said that the presence of hydrogen had at any rate an important effect and was undoubtedly one of the causes, probably the most important one, but was not the only cause of hair cracking.

Many references were to be found as to the different behaviour of various kinds of pig-iron having the same chemical composition but of different origin. To-day there was no doubt that this behaviour had its origin in the gas and oxide content of the pig-iron. Foundry pig-iron from small blast furnaces, especially cold-blast iron, generally contained less gas. With larger furnaces and higher temperature, and also with higher pressure and especially with a small proportion of slag, the difficulties in foundry practice thereby arose. The superiority of Swedish pig-iron had its origin in its greater purity; it carried less sulphur and other deleterious components.

Difficulties such as those with which the ironfounder had to contend did not arise in nearly the same degree as in steelmaking practice, because boiling removed the dissolved gases and the carbon reduced the oxides. In the melting of cast iron, the removal of these impurities was impossible, because there was no boiling and the temperature was too low.

Ferro-manganese was not mentioned in the Paper; but it had been established that from 80 to 100 ml. of gas might be contained in 100 grams of ferro-manganese. The gas content of carbon-rich ferro-alloys was generally lower than in alloys which were poorer in carbon. Nitrogen was determined, but was not mentioned in the Paper. Moreover it might be mentioned that in some iron alloys, for instance in ferro-chromium, the nitrogen was combined as chromium nitride. In other alloys the nitrogen occurred as a gas dissolved in the metal. Generally speaking, the nitrogen contents were about the same as those of hydrogen.

MR. BENSIMON (France), referring to the statement that hydrogen, though the most important cause, was not the only cause of hair cracks, asked whether it was possible to distinguish between the different causes to which the different kinds of defects were attributed. Did all the causes operate together or did they operate singly, each giving rise to a particular kind of defect?

DR. BARDENHEUER repeated that hair cracks could not be attributed entirely to the presence of hydrogen; hair cracks were ruptures caused by forces which occurred in the material. As he had established in 1925* hair cracks and flakes in chromium-nickel steels could be caused by crystal segregation. In later Papers he showed that local ruptures quite similar to the formation of pickling blisters were caused by hydrogen under high pressure. This hydrogen, however, became liberated during the period of diminishing solubility brought about by lower temperature. Finally, shrinkage stresses could contribute to this effect. Thus the cracks occurred at those places where the amount of stresses exceeded a certain limit. In most cases shrinkage stresses in the ingot only determined the direction in which the hair cracks ran; if the shrinkage stresses of ingots were so strong that this force alone would destroy the ingot, the cracks always had a very large extension.

* "Die Flocken im Nickelchromstahl," Mitt. K.-Wilh. Inst. Eisenforschung, Düsseldorf, 1925, pp. 1-15.

ing re-circulation and a good drying stove were interesting. He believed the success of the ... lar to those obtained by Dr. Skeil some years ago.

over, these cast steel frames had been exported

Renaissance of the Steel Casting and the Rôle of the Metallurgist*

By FREDERICK A. MELMOTH†

(Presented on behalf of the American Foundrymen's Association)

Over the period of the last two decades, it has been not uncommon in certain circles to hear dire prophesies of the pending extinction of the founding industries. Acute competition has developed in various directions, each of which is a logical and expected happening in a progressive industrial civilisation. It is becoming obvious, however, that, far from the steel casting becoming an extinct relic of the Dark Ages of engineering industry, such knowledge of its production, and control of its major characteristics, are now forthcoming that an increasing scope of application is resulting.

In the late 1920's, a period of probably the greatest industrial activity the United States of America has experienced, the production of steel castings averaged about one and a quarter millions of tons. Since this time, many developments of a competitive nature have appeared, and, where suited, technically and economically, have taken a certain toll of the production of the industry. In spite of this, however, the year 1937, not by any means a good year, but one truly described as only an improvement on the two immediately preceding it, saw the production of steel castings almost touch the one million ton mark.

Affected by general stagnation, and the accumulated influences of several highly and efficiently advertised competitive products, such a figure indicates beyond question that new applications of steel castings have at least stabilised the position of the industry, and gives reasonable grounds for the belief that a return to normal business conditions will see it attain new heights of production. One of the most powerful influences in this development is believed to be the fact that the industry as a whole is becoming technically strong.

Steel founding has frequently been described as a mixture of art and science. A definition of the two terms possesses no hard and fast dividing line, but assuming one logically could define art as dexterity or skill in performance, acquired by experience, and science as systematised knowledge, then it is believed that progress for the future is most surely based on the encouragement and more complete application of the latter.

The present Paper proposes to offer evidence that this desirable condition is being achieved, and that the results forthcoming are a primary factor in the constantly widening field of application of steel castings in the United States. The incidence of the efforts of the metallurgist on this changing thought in foundry production is remarkable, and a study of the literature of the last ten years or so impresses one with the conviction that the broader conception of responsibility evinced by the metallurgist is producing a large part of the more systematised methods of attack on fundamental foundry problems.

A New Division of Metallurgy

Within the wider definition of iron and steel metallurgy, there is being built up what might be called a foundry metallurgy, devoted to the essential problems of cast-to-shape, unworked materials. Any metallurgical investigation into the conditions governing the production of sound steel castings runs immediately into the closely related factors of mould and core effects, temperature gradients and their effect upon solidification, localised temperature differences due to design, and many other points which, while not to be defined strictly as metallurgical, exert so profound an influence upon the success or failure of the ultimate casting as to compel their being taken fully into account.

It was a logical outcome, then, that the metallurgist should extend his active interest beyond the confines of the metal itself, and from this has grown most of the systematic investigation of moulding materials and methods of pouring and feeding steel castings. By taking each major operation singly, and correlating the work done in the United States during the last few years, as evidenced by published literature, it will be possible to demonstrate these statements clearly.

Steelmaking

The manufacture of suitable steel for castings, in many of the principal features, is quite separate and distinct from steelmaking as practised by the makers of ingot steel. In the latter case, physical work of a structure-modifying nature reduces the significance of certain conditions, which in the case of the sand casting may mean the difference between success and failure.

It is also of vital significance that the producer of steels destined to be mechanically worked, as by rolling or forging, exerts a complete and unquestioned control over the shape and general design of the ingot form in which his cast metal undergoes solidification. He is able, therefore, to assist sound and progressive solidification to whatever extent he may see fit.

The case of the steel foundryman is vastly different. Faced by a legion of differing shapes, and a multiplicity of sectional thicknesses in the same casting, and a very varying degree of response to his calls for design consideration, his molten steel has perforce to solidify many times in such fashion that no advantage can be taken of orderly and progressive conditions of transformation. In such circumstances, steel must possess, initially, every possible steelmaking inherent quality of soundness, cleanliness and regularity of temperature and composition.

In the last decade the recognition of such severe quality requirements has led to concentrated effort to regularise steel production for castings, and to attempt, at least, to elucidate such steel production problems as could be believed logically to have a bearing on casting behaviour. Prominent among American foundry metallurgists, who have advanced the knowledge of this subject, one finds such names as Sims, Lillieqvist, Batty, J. Howe Hall, to mention only a few.

The importance of slag constitution and deoxidising procedure has been investigated in the case of both electric and open-hearth practice. The significance of inclusions, their degree of occurrence and shape, had been considered not only from the viewpoint of their effect on ultimate properties, but also because of the possibly better behaviour of clean steel in the mould. In this connection, it is a widely held opinion that basic open-hearth steel is superior to that produced on acid linings in resisting hot-tear formation in castings of intricate and varied designs. There appears no basis for the opinion held at one time that sulphur and phosphorus content explained this diversified behaviour, as material control in acid practice, resulting in equally low percentages of both, did not eliminate the disparity.

There would appear to be no question that in cases where steelmaking practice, and particularly methods of deoxidation, were of a type disregarding the degree of occurrence and type of inclusions, there occurred a greater hot-tearing hazard. Discussion invariably brings out the fact that clean steel, foundry conditions being otherwise equal, suffers much less from this particularly dangerous tendency.

It is from the viewpoint of obtainable physical properties, however, that steelmaking methods have been most rigorously overhauled. In the absence of mechanical work of a structure-affecting type, a steel casting must respond perfectly to heat-treatment if the demands of modern specifications are to be met. Non-metallic inclusions, unaffected by any type of heat-treatment, are without doubt the most effective single factor in limiting the physical properties of steel castings.

The work of C. Herty, jun., on the conditions governing the formation, size and type of such non-metallics has been of great value to steel foundrymen. The realisation, also, that the major harmful effect of aluminium additions to steel for castings was an outcome of the action of aluminium on non-metallic inclusions, their shape being changed from a comparatively innocuous globule to a more or less membranous

TABLE I.

BIBLIOGRAPHY OF AMERICAN LITERATURE ON STEELMAKING PRACTICE FOR CASTINGS.

Title.	Author.	Publication.	Date.
Furnace Manipulation Governs Inclusions in Acid Open-Hearth Steel.	C. H. Herty, Jr., and J. E. Jacobs	The Foundry	November 15, 1931.
Taking Care of Inclusions in Steel..	Dr. C. H. Herty, Jr.	The Iron Age	December 17, 1931.
Inclusions—Their Effect, Solubility and Control in Cast Steel	C. E. Sims and .. G. A. Lillieqvist	The American Institute of Mining and Metallurgical Engineers.	February, 1932.
Some Factors Affecting the Cleanliness of Steel Castings.	C. H. Herty, Jr. C. F. Christopher, M. W. Lightner.	American Foundrymen's Association Reprint No. 32-4.	May, 1932.
Points to Causes of Porosity ..	R. A. Bull	The Foundry	January, 1935.
The Preparation of Steel to Avoid Porosity in Castings.	C. E. Sims	Transactions, American Foundrymen's Association	1934.
Physical Appearance of Slag Indicates Quality of Steel.	Earl C. Smith ..	Steel	March 18, 1935.
Report of Committee on Methods of Producing Liquid Steel for Castings	American Foundrymen's Association	Transactions, American Foundrymen's Association	April, 1937.
Slag Viscosity Control Affords Greater Uniformity in Steel.	C. H. Herty, Jr. ..	Steel	June 7, 1937.
Open-Hearth Practices in a Steel Castings Plant.	John W. Porter ..	The Iron Age	November 25, 1937.
Four Decades of Steel Making ..	Pat Dwyer	The Foundry	May, 1938.
Effects of Aluminium on the Properties of Medium Carbon Cast Steel.	C. E. Sims and F. B. Dahle	Transactions, American Foundrymen's Association	September, 1938.

* Paper presented to the International Foundry Congress held in London and organised by the Institute of British Foundrymen.

† Detroit Steel Casting Company, Detroit, Mich.

form occurring in the crystal junctions, paved the way for additional work on the correct use of deoxidisers. Comstock, Sims and Lillieqvist were largely responsible for this elucidation of the aluminium problem, which, particularly to steel foundries equipped with acid electric furnaces, was of real significance.

Further work by Sims and collaborators throws still more light on the subject, and evolves the suggestion that increased aluminium additions in certain conditions will result in a return to normal ductility. The majority of American steel castings are produced in green sand moulds, and the use of aluminium in such circumstances is of undoubted assistance in promoting soundness, by inhibiting porosity due to mould gases. Very often, however, such castings are made to stringent physical test specifications, and the obtaining of freedom from porosity, at the sacrifice of a large portion of the specified ductility, is of more than dubious value.

The present situation on this much discussed question of the effect of aluminium in steel for castings is best indicated by saying that many steel foundries in the United States using acid-lined electric furnaces are carefully and extensively checking the results obtained by large aluminium additions, up to three or more pounds per ton of liquid steel. So far, the reported opinions show a preponderance who claim a decided improvement in ductility, as compared with the normal addition of a half to one pound per ton of steel. There are still producers, however, who fail to experience such benefits, and it seems very probable that steelmaking technique has a decided influence on the response obtained.

The development of the electric furnace in steel foundries of the United States has been largely toward acid linings. Indeed, a recent *questionnaire* addressed to the members of the Sixth Division of the Steel Founders' Society of America disclosed only one basic-lined furnace producing steel for castings in the entire district, covering some thirty foundries—many of them large. This calls for some comment, as it is contrary to conditions in Europe.

The frankly held opinion of American steel founders substantiating their preference for acid practice is that while suitable scrap is available, offering adequate sulphur and phosphorus control, such practice has the following advantages:—

(1) It is speedier, and therefore more economical.

(2) The life of the furnace is much longer using standard refractories.

(3) The technique of the process is more easily acquired by untutored labour.

(4) The steel is much more fluid, and therefore better suited to the pouring of light, thin-section castings.

Item 4 is the most controversial, but in the author's opinion is substantially correct when standard practices of acid and basic types are being compared. The sluggishness in pouring exhibited by basic electric mild steels in certain conditions of manufacture led to the term "over-reduced." "Under-oxidised" would probably be more technically correct.

In normal conditions of practice it would appear that steelmaking methods have resolved themselves into a definite order in the minds of steel foundrymen, based on their ability to produce easily poured steel. Heading the list is the converter, and in America the basic-lined electric furnace occupies bottom position. It is significant that the position on the list occupied by any process is in inverse relation to the degree of reducing conditions normal to its use, at any period of the steelmaking process.

The question of the influence of long maintained reducing conditions on the fluidity of steel for castings is no longer treated with scepticism, and inquiry confirms an almost universal avoidance of such furnace conditions. The improvements in steel castings performance, and consequently in their scope of engineering application, due to a better knowledge of steelmaking technique for castings, have been very considerable, and offer a substantial contribution to the industry by means of metallurgical progress. The subject is extremely live in the United States of America, the Steel Division of the A.F.A., and the trade organisation of the industry, the Steel Founders' Society of America, both devoting special attention to giving it full prominence in committee work and conferences.

Table I gives a bibliography of American literature on steelmaking practice for casting production.

TABLE II.—*Composition and Physical Properties of Modern American Steels for Castings.*

Steel.	Analysis. C.	Mn.	Si.	Mo.	Cr.	Ni.	Va.	Heat-treatment.
								deg. C.
1. Mn–Mo ..	0.28	1.29	0.46	0.30	—	—	—	926 Furnace cool.
								926 Air cool.
2. Mn–Mo ..	0.28	1.29	0.46	0.30	—	—	—	815 Air cool.
								650 Air cool.
3. Mn–Mo ..	0.28	1.29	0.46	0.30	—	—	—	926 Air cool.
								815 Water quench.
								649 Air cool.
4. Mn–Ni ..	0.23	1.16	0.44	—	—	0.71	—	900 Furnace cool.
5. Mn–Ni ..	0.23	1.16	0.44	—	—	0.71	—	900 Air cool.
6. Mn–Ni ..	0.23	1.16	0.44	—	—	0.71	—	900 Water quench.
								650 Air cool.
								926 Air cool.
7. Ni (2.5 per cent.)	0.21	0.64	0.35	—	—	2.55	—	837 Air cool.
								593 Air cool.
8. 5 per cent. Cr–Mo	0.18	0.55	0.41	0.48	5.1	—	—	982 Furnace cool.
								857 Air cool.
								726 Furnace cool.
								926 Air cool.
9. Cr–Va ..	0.33	0.72	0.41	—	0.93	—	0.19	837 Air cool.
								650 Air cool.
10. Ni–Mo ..	0.24	0.64	—	0.33	—	2.15	—	Normalised and tempered.
11. Ni–Va ..	0.33	1.05	—	—	—	1.58	0.10	Oil quenched. Tempered 677 deg. C.

No.	Physical Properties. Yield point. Tons per sq. in.	Ultimate strength. Tons per sq. in.	Elongation per cent. in 2 in.	Reduction of area. Per cent.	Charpy impact. Ft.-lbs.	Hardness. Brinell.	Shore scler.
1.	26.8	40.6	21.5	34.40	19.8	187	27
2.	28.9	37.7	28.0	60.58	45.3	179	26
3.	37.4	44.6	23.5	57.04	51.4	212	31
4.	23.2	36.2	30.5	51.67	—	146	22
5.	23.3	39.0	29.5	57.30	—	153	23
6.	32.6	41.5	27.0	61.81	—	207	30
7.*	24.4	33.8	28.2	52.39	25.0	207	30
8.†	28.5	40.4	24.6	60.59	25.6	146	22
9.	29.9	42.1	23.0	44.85	—	196	29
10.‡	31.2	41.3	24.0	50.00	36	—	—
11.‡	45.4	51.4	19.5	48.00	—	—	—

* Charpy test at 50 deg. below zero.
† Charpy test at 25 deg. below zero.
‡ Paper by F. J. Walls and T. M. Armstrong, Western Metal Congress, 1938.

Alloy Steel Casting Development

One of the major effects of increased metallurgical thought on steel-casting production has been the growth of the idea of "making the casting to fit the job." In other words, it has been realised that mere thickness changes with a standard material do not even approach a solution of certain difficult service conditions. A study of the conditions, in the light of available metallurgical knowledge, has led to a steady and continuous increase in the use of alloy compositions of many types.

In earlier days this growth was menaced seriously by a lack of appreciation of the vital importance of suitably-allied heat-treatment, and foundries, slow to embrace the growing metallurgical influences in the industry, assumed a significance in alloy content, which did not exist apart from correct heat-treatment. Very largely this attitude has disappeared, and reasonably accurate knowledge of this relation is practically industry-wide to-day. The natural result has been an expansion of the scope of application of the steel casting, and its use in very many cases where previously it was not believed advisable.

The steel foundries of the United States have carefully fostered the low alloy types of steel, which, with correct heat-treatment, contain within their range a material highly suitable for almost every engineering application, apart from corrosion or high-temperature resistance.

The practical utilisation of these steels in casting form represents a metallurgical problem with three closely related phases—mass, composition and heat-treatment—and the foundry metallurgist has assisted progress remarkably by realising and elucidating the correlated effects of all three.

The number of alloy combinations in these low-alloy steel castings is to-day very large, many of them manifesting approximately the same physical properties. Choice, therefore, is often dependent upon individual preference on the part of either the founder or the purchaser. A few of the more popular may be briefly described, as a matter of interest, entirely without prejudice to the many others whose properties are probably just as valuable, but whose inclusion could unduly prolong this section.

Manganese-vanadium castings, containing from 1.2 to 1.5 per cent. manganese, and 0.1 to 0.2 per cent. vanadium, constitute a valuable member of the group, responding easily to various heat-treatments with a wide range of resulting properties, and especially high dynamic values.

Manganese-molybdenum steel is an exceedingly popular one for use in castings in the United States. Response to heat-treatment is very complete and easily accomplished, and the steel possesses good foundry characteristics. Where design and mass are suitable, this material, in casting form, can be quenched safely in water or oil, and, followed by a tempering treatment designed to suit the service intended, results in a

casting of high tensile and yield ratio, with excellent ductility and resistance to impact.

Some straight copper steels are in use, but commonly this element is present in combination with at least one other alloying element, such as chromium or molybdenum. Such castings correctly heat-treated possess excellent properties, both static and dynamic. They also possess in a high degree good founding qualities, a point of very great importance in view of the difficult and complicated designs commonly encountered to-day.

Nickel steels of varying carbon content are in wide use, in cases where great toughness and shock resistance are essential. Nickel in combination with chromium, sometimes with the addition of 0.2 to 0.3 per cent. molybdenum, has a firm place in the confidence of many founders, and excels where high strength and toughness are demanded in service. The ternary combination also has a following for high-temperature pressure-castings, having good creep resistance properties.

Straight carbon-molybenum steels are being found of increasing value for high temperature and pressure conditions involving creep resistance, and have the added qualities of simplicity in manufacture and good foundry behaviour. A material finding an increasing application, particularly in oil refinery work, where often temperature and pressure occur in somewhat corrosive conditions, is the 4 to 6 per cent. chromium, 0.5 per cent. molybdenum combination. Correctly heat-treated, this steel has remarkable physical properties. For casting uses, low carbon is a distinct advantage, and rarely exceeds 0.2 to 0.25 per cent., great strength being conferred by the alloy content.

A representative set of physical properties appears in Table II, and it is of added interest to note that in the case quoted an impact specification at 25 deg. F. below zero was imposed. The treatment required to break down thoroughly the cast structure of this material is of great importance in such a case, as it was found that high static qualities, even the possession of such elongation and reduction of area as 32 per cent. and 63 per cent. respectively, represented no guarantee of successfully meeting the impact specifications at sub-zero temperatures. As a matter of fact, almost every steel used in worked form finds its counterpart in use for steel castings in the United States of America to-day, and the engineer has a wide choice of types to meet any service conditions.

Chrome-molybdenum steels of varying carbon content, and possessing good resistance to abrasion, and manganese steel of the Hadfield type, where service conditions involve the necessary work-hardening surface distortion, are produced in large quantities. The higher alloys for heat- and corrosion-resistance are all available in casting form, and constitute a growing branch of the industry. In some plants, many of these alloys are produced in centrifugally spun moulds, with advantages of appearance and soundness where design is suitable.

This section of the Paper should not be concluded without reference to the series of Ford alloys, classified as steels, some containing a high carbon content, which in the presence of silicon as high as 1.10 per cent., causes these materials to be graphitic in type, but possessing appreciable ductility after suitable heat-treatment. Practically all are copper bearing, in amounts from 0.5 to 2 per cent., and some also contain chromium. Introduced originally for crank shaft manufacture as sand castings, their application has been rapidly extended, very great quantities now being produced both at the Ford plant and by other suppliers.

Many interesting details were given in a recent Paper by Mr. McCarroll, of the Ford plant at Dearborn, Michigan, and interested readers are referred to the published details. There is little doubt but that the increasing use of alloy content in an intelligent effort to meet varying service demands has exerted a great influence on the possibilities of utilising steel castings to a greater extent.

Originally, the recommendation of using alloy steels was accompanied by an insistence upon the possibility of decreasing weight by so doing, in many cases this being fallacious as an argument, as it often happens that rigidity has an importance even higher than mere unit strength. Whilst in many cases some saving in weight can be achieved advantageously on existing castings, yet in an even greater number, the sounder argument in support of alloy compositions is the re-establishing of safety margins without adding to weight, in engineering applications where progress demands higher speeds, heavier loads, higher pressures, higher temperatures and so on, each of which rapidly absorbs the available margin of straight carbon steels.

A study of service conditions almost always can result in a foundry recommendation of a suitable alloy steel, the special characteristics of which have a definite value in each particular case. Such work is essentially metallurgical, and represents an incontrovertible proof of the value of metallurgical knowledge to the industry.

Table III gives a bibliography of American literature on alloy steel castings.

(To be continued.)

TABLE III.

BIBLIOGRAPHY OF AMERICAN LITERATURE ON ALLOY STEEL CASTINGS.

Title.	Author.	Publication.	Date.
Nickel Alloy Steel Castings ..	A. G. Zima	The Steel Founder	January-February, 1932.
Excellent Properties Developed by Vanadium Alloy Steel Castings	Jerome Strauss and Geo. L. Norris	The Steel Founder	March-April, 1932.
Chrome-Nickel Steel for Navy Cast Steel Anchor Chain.	T. N. Armstrong ..	The Iron Age	January 12, 1933.
Better Steel Castings Reflected in Specifications.	David Zuege ..	Metal Progress	February, 1934.
Studies Physical Properties of Low-Alloy Cast Steels.	T. N. Armstrong ..	Steel	December 3, 1934.
Specialises in Alloy Steel Castings	Pat Dwyer	The Foundry	March, 1935.
Ford's New Facilities for Casting Alloy Steels.	—	The Iron Age	April 30, 1936
Ford Alloy Castings	R. H. McCarroll and J. L. McCloud	Metal Progress	August, 1936.
Heat-Resisting Castings, Cr-Ni-Fe Alloys.	J. D. Corfield ..	Metal Progress	October, 1936.
Strong Steel Castings Ride the Rails	Raymond L. Collier	Metal Progress	February, 1937.
Alloy Steels Designed for Specific Uses.	Vincent T. Malcolm	The Foundry	July, 1938, August 1938, September, 1938.
Progress in Automotive Steel Castings.	R. H. McCarroll ..	The Foundry	October, 1938.

THE SOUTHERN RAILWAY COMPANY has placed with Tees-side firms an order for 12,000 tons of railway chairs. The principal participants in the order are the Tees-side Bridge & Engineering Company, Limited, and Pease & Partners, Limited.

Rally in Metal Prices

BY "ONLOOKER."

It is nothing unusual for prices on the London Metal Exchange to stage a rally either just before or just after the August bank holiday, for the fact of the matter is that this month is not such a holiday period in the States as it is here, and often enough there is a foretaste of the American autumn trade revival which is sufficient to set things going. Something of the sort seems to have happened this year, but London was quite ready to respond to any spur, and as a matter of fact there were some good buying orders from Germany in the London market, copper and lead being the metals most in demand.

One cannot, of course, overlook the fact that the futures market in London has been inclined for months past to consider the uncertainties of the international situation much more than the excellence of the rate of consumption. In practice this has worked out that the speculator has held off, and it is not even certain now that he has come in to any extent, for those competent to judge say that the bull account is small, liquidation having been well sustained on the way up and the market being all the healthier in consequence.

It has been evident for a long time that, with the exception of tin, the base metals have been standing at a fairly low level in view of the excellence of the demand, and to that extent consumers must consider themselves fortunate that they have not been obliged to pay a higher price before this. There was a time, of course, when a well-sustained demand for physical metal resulted in big covering purchases in Whittington Avenue, for merchants handled the bulk of the business in non-ferrous metals, and it was their custom to use the futures market freely.

There has, however, been a change during the period since the war, and nowadays the producer more often than not makes a direct contact with the consumer, the need for hedging thus being eliminated. It is argued that under the old method markets found their true level more successfully than they do now when producers have to do their best by means of output restriction schemes to keep the quotation at a level which they deem satisfactory. Whether the user is better off is a matter for conjecture. The sellers certainly have some awkward problems to face, as witness the tremendous burst of copper buying in the States in July, when consumers crowded in and bought over 180,000 short tons, the bulk of the buying being concentrated within a few days. They were lucky to get it at a relatively small price advance, but the U.S. producers have now realised that if the quotation is allowed to go up too quickly a reaction always follows.

The other side to the price picture is the question of what is the level at which demand is best sustained, bearing in mind that the producer should get a fair return. Just before the holiday standard copper climbed up virtually to £45, and lead went past £16 without demand receiving an appreciable check, but there are probably few people who would suggest that at these levels producers are not netting adequate profits. World stocks of copper are expected to register a further reduction when the July figures are published, and there is a good deal of talk of production being lifted from its present level of 95 per cent. to something more nearly in line with the present-day needs. There is also a measure of output restriction in lead, but if any change is made in this we may not hear much about it. An alteration in the rate of copper output is, however, likely to be well advertised.

Industrial Legislation in South Africa*

By A. H. GUY†

(Presented on behalf of the South African Branch of the Institute of British Foundrymen)

The foundry trade in South Africa is comparatively young, as indeed is most industrial development in the Union. It virtually owes its inception to the gold mining industry on the Witwatersrand, and its earlier growth, and even its present major activities, are roughly parallel to the development of gold mining.

The industry therefore may be said to date back only as far as 1886, at which time it was extremely elementary, being employed on such jobs as the making of firebars and such simple castings as could only be imported with considerable delay, holding up work in consequence, and which might be contrived under the difficult conditions then prevailing.

Since the beginning of the present century, foundry activity has developed roughly in proportion to the expansion of gold mining, and its technique is largely designed to cater for that market. In recent years, however, foundrymen have been seeking extended markets, and there is no doubt that scope exists. Hitherto the bulk of production has been on a general engineering basis, probably because of the restricted market offering, but as technique develops further and conditions of employment are adapted to the needs of manufacture, it is reasonable to expect considerable progress by the industry in a number of directions hitherto unexplored.

Conditions of employment are, of course, based upon existing legislation for the control of industry, and such legislation is advanced. The following Acts have a direct application to industry:—Factories Act, Apprenticeship Act, Workmen's Compensation Act, Industrial Conciliation Act and the Wage Act.

Factories Act

The Factories Act was first introduced in 1918 and brought up to date in 1929. It provides for the licensing of factories and generally for matters germane to factory hygiene. A 48-hr. week is laid down, with time and a quarter to be paid for overtime, public holidays are regarded as holidays without pay—there are eleven statutory holidays during the year in South Africa—while provision exists for the care of female labour and juveniles (the latter under 16 years of age may not be employed). Regulations require the proper safeguarding of health and life, and are administered by Factories Inspectors under the control of the Department of Labour.

Changing room accommodation must be provided to "the satisfaction of the inspector," which, in the case of foundries, entails the provision of hot and cold water in changing rooms, showers and individual lockers for employees. The Regulations also provide for first-aid equipment, the supervision and control of machinery and boilers, generation and distribution of electricity, elevators, and also lay down procedure in the event of accidents and inquiries in relation thereto.

Apprenticeship Act

The Apprenticeship Act, which was introduced in 1922 and brought up to date in 1930, is designed to regulate apprenticeship and the carrying out of contracts of apprenticeship in designated trades. The Act makes provision for the scheduling of the industries in which it is to apply, and thereafter committees are set up to advise the Minister on the designation of the trades in the industry concerned which are to be controlled under the Act. Such committees consist of an equal number of representatives of employers and employees under a chairman appointed by the Minister, and it is their function to recommend *inter alia* the qualifications a youth should possess before he may be indentured, in regard to age and education, and further to recommend what number of apprentices may be employed in any shop, the rates of wages, the period of apprenticeship, courses of training and any other conditions which it deems desirable.

Further functions of apprenticeship committees embrace disputes which may arise over contracts, the type of educational class which an apprentice may be called upon to attend, the examination of proposals for indentures of youths submitted by employers, and generally the ability to inquire into any matter relating to apprenticeship in the industry in the area for which the committee has been appointed.

Briefly, the procedure which must be followed before a boy can be apprenticed to the moulding trade is as follows:—The employer makes application to the committee for the indenture of a certain youth on a prescribed form. The committee, if it is satisfied that the boy is over sixteen years of age and has passed Standard VI, and that sufficient training facilities exist in the establishment of the employer to ensure that this particular individual will be given the opportunity of becoming a properly qualified journeyman, will then recommend the indenture, which is thereafter more or less automatic.

A contract is then entered into between the employer and the boy's guardian, being binding in civil law for a period of six years, and subject to the supervision of the apprenticeship committee. During the first five years of his indenture the boy must attend technical classes. For the first two years he is given a certain amount of time off by the employer, but thereafter he must attend evening classes for three nights each week.

Practically no other type of moulder than a journeyman exists in South Africa to-day. Negotiations are on foot between the employers' organisation and the trade union with a view to dilution in order to encourage manufacture, but at the time of writing no concrete steps have been taken, except in Durban where a large foundry is engaged in various forms of repetition work with employees under repetitive conditions.

The question of technical training in the trade in conjunction with apprenticeship is occupying the close attention of the South African Branch of the Institute, which aims at developing the status of foundrymen in South Africa, and creating the necessary technical educational facilities to enable professional qualifications to be obtained to that end.

Workmen's Compensation Act

The Workmen's Compensation Act is the next statute with which the industry is concerned. Workmen's compensation insurance in South Africa is compulsory, but while there are one or two mutual associations in existence, the bulk of the business is conducted by private companies, under an arrangement with the Workmen's Compensation Commissioner, whereby they undertake to return 65 per cent. of the aggregate premiums in benefits. Premiums are of course adjusted in accordance with the risk.

A workman is entitled to compensation under the following circumstances:—

If an accident occurs to him during the course of his employment, providing that such disablement is not due to his serious or wilful misconduct—unless he is killed or seriously disabled under these circumstances leaving dependants, but this exception will not apply if the accident was directly attributable to drunkenness.

He is also not entitled to compensation if disablement or death is due to a pre-existing diseased condition of which his employer was unaware but of which the workman had cognisance.

Accident resulting in serious disablement or death counts for compensation even though the workman at the time was acting unlawfully or against instructions, providing that he was so doing for the purpose of and in connection with his employer's business.

If negligence on the part of the employer be the cause of the accident, application may be made for increased compensation. Compensation is payable to dependants, including widows, children under sixteen, parents, brothers and sisters, provided that it can be shown that they were wholly or partially dependent on the workman's earnings at the time of the accident.

The administration of the Act is entrusted to the Commissioner of Workmen's Compensation, provision being made for questions in dispute to be determined by a magistrate, and for medical and technical assessors and medical arbitration, appeal to a higher court being admissible on certain specified grounds. Control of the payment of compensation is in the hands of the Commissioner.

Compensation for temporary partial or total disablement is at the following rates:—At the rate of 60 per cent. of the monthly earnings, up to £20 of such earnings, together with 35 per cent. of his monthly earnings in excess of £20 up to £33 6s. 8d.: Provided that such compensation may be increased to an amount not exceeding the rate of the workman's earnings or £6 10s. per month, whichever may be the less:—

(i) When the workman was at the date of the accident causing disablement under 21 years of age; or

(ii) When the workman, although above that age, would be unable to maintain himself and those dependent on him upon the periodical payment.

The period of temporary disablement is six months, which may be increased to twelve months, and may be further increased on a different scale of payment.

The compensation in the case of permanent disablement, including permanent injury or serious disfigurement, shall be according to the degree of disablement of the workman and in accordance with the following rules:—

(*a*) Where the degree of disablement is 40 per cent., a lump sum equal to sixteen times the monthly earnings of the workman up to £20 of such earnings, together with nine times his monthly earnings in excess of £20 up to £33 6s. 8d.

(*b*) Where the degree of disablement is under 40 per cent., a lump sum bearing the same proportion to a lump sum calculated in accordance with paragraph (*a*) as the degree of such disablement bears to 40 per cent.

(*c*) Where the degree of disablement is over 40 per cent. and under 70 per cent., then in respect of one-half of the percentage of disablement, a lump sum calculated according to paragraph (*b*), and in respect of the other half of the percentage of disablement, a monthly pension calculated in the manner provided in paragraph (*e*).

(*d*) Where the degree of disablement is 100 per cent., a monthly pension equal to one-half of the monthly earnings of the workman up to £20 of such earnings, together with one-quarter of his monthly earnings in excess of £20 up to £33 6s. 8d.

(*e*) Where the degree of disablement is 70 per cent. or over, but under 100 per cent., a monthly pension bearing the same proportion to a pension calculated in accordance with paragraph (*d*) as the degree of such disablement bears to 100 per cent.

* Paper presented to the International Foundry Congress held in London and organised by the Institute of British Foundrymen.

† Eclipse Tube Mill Liners (Proprietary), Limited, Benoni.

The compensation where the workman dies from an injury caused by an accident shall be as follows:—

(*a*) If the workman leaves as a dependant a widow or invalid widower and no children, an amount not exceeding two years' earnings of the workman or £500, whichever is the less.

(*b*) If the workman leaves as dependants a widow or invalid widower and one or more children, an amount not exceeding eighteen months' earnings of the workman or £375, whichever is the less, to such widow or widower together with a pension in respect of such children as provided in paragraph (*c*): Provided that, if the amount of compensation payable under this paragraph is less than the amount payable under paragraph (*a*), such amount may be increased to an amount not exceeding that payable under paragraph (*a*).

(*c*) If the workman leaves as dependants one or more children, a monthly pension in respect of the children amounting to the undermentioned percentage of the pension which would have been granted to the workman if totally and permanently disabled as provided in paragraph (*d*) of sub-section (1) of Section 48, according to the number from time to time of such children who are entitled to receive a pension, that is to say:—

1 child	20 per cent.
2 children	35 ,, ,,
3 children	50 ,, ,,
4 children	60 ,, ,,
5 children	65 ,, ,,
6 children or more	70 ,, ,,

subject to certain provisos which regulate the position.

Medical aid is also provided by the Act, and first-aid and transport for an injured employee. Medical expenses, in addition to compensation, may be defrayed for a period up to a year on a scale deemed reasonable by the authorities, up to £100. The fees and charges to be made by practitioners are prescribed by regulation, the workman having freedom of choice in the selection of his medical and surgical treatment, unless provision has already been made therefor by his employer on a scale approved by the Commissioner.

The Act further provides for industrial diseases, and the compensation of native (African) employees on a scale different from Europeans, to whom the foregoing provisions mainly apply. It should be borne in mind that most of the lower-paid occupations in South Africa are filled by natives. Provision for compensation in the Act is relative to the general requirements for civilised as opposed to less civilised standards of existence. Insurance is, of course, compulsory and is conducted, as indicated, through private insurance companies which require to be licensed to conduct workmen's compensation business.

Industrial Conciliation Act

The measure which probably plays the greatest part in the regulation of industrial relations is the Industrial Conciliation Act, which was introduced in 1924 and brought up to date in 1937. It is perhaps significant that no major strikes have taken place in South Africa since this Act became law, which appears to indicate that the primary purposes of the measure—the prevention and settlement of industrial disputes—have been served.

Broadly, the Act provides two classes of machinery for the control of relationships; conciliation boards and industrial councils. A conciliation board is brought into existence either on the application of a trade union or of an employers' organisation. Alternatively, the Minister may decide to create such a board. A condition precedent is that the matter in dispute is one which falls to be dealt with under the Act, and it is provided that no strike or lock-out may take place until the Board has reported to the Minister on the matter in dispute.

If agreement is reached by the parties through a board, then the agreement may be given the force of law for a specified period. Mediators may be appointed at the discretion of the Minister and arbitrators may be called in if the parties agree.

The second class of machinery is the industrial council. It is possible for individual trade unions and employers' organisations, or groups of such associations, to come together and draw a constitution in terms of the Act, which is then registered by the Industrial Registrar and has the effect of creating the industrial council as a body corporate. It becomes the function of this body, consisting of an equal number of representatives of employers' associations and trade unions, to endeavour to settle any disputes which may arise in the particular industry concerned, and to enter into agreements regulating wages and conditions.

The method of handling disputes is similar to that employed under the conciliation board system, the existence of the council making strikes and lock-outs illegal until the council has failed to settle them and has reported to the Minister accordingly. Mediation and arbitration proceedings may be invoked as under a conciliation board.

If (as is the invariable practice) an industrial council decides to negotiate an agreement to govern wages and conditions in the industry, it may, on completion of the agreement, request the Minister of Labour to give it the force of law for a given period. The Minister gazettes the agreement by virtue of the powers conferred on him in terms of the Act, and it then has the force of law, penalties for breach being prescribed under the Statute.

The Minister may go further with reference to an agreement—and indeed usually does. He may indicate in gazetting an agreement that, since he is satisfied that the parties are sufficiently representative of the industry, it is to be binding not only upon the parties but on all employers and employees in the industry in a given area, irrespective of whether they are members of any of the employers' organisations or trade unions comprising the industrial council.

Power is given to industrial councils by the Act to appoint agents, and the Minister may, if he approves of such agents, invest them with the powers of an inspector in the government service, so that they may enter upon premises either of parties or non-parties, call for books and make investigations with a view to ascertaining that any industrial agreement in force is being properly carried out.

The Act requires that any association of employers or employees who come together with the object, *inter alia*, of regulating conditions of work, must register under the Act, submitting their constitutions to the Registrar within three months of formation. The Registrar, if he is satisfied that the constitutions contain nothing contrary to the objects of the Act, or to the public interest, then registers the body concerned for a given area, and it becomes the body representative of the particular interest concerned in that area. No unregistered body has any status in law.

The Act defines, among other things, the term "employee" and excludes from such definition persons falling under the pass laws of the Union —that is to say pass-bearing natives. Any question affecting the interests of native employees therefore does not fall within the scope of the Act, being rather a matter for the Native Affairs Department, although industrial agreements commonly lay down wages for the type of occupation which is usually filled by native employees —such as labouring work.

The Minister is given power, however, to extend the terms of an agreement to natives, to prevent their exploitation in occupations common to European classes of labour, which might be possible if an agreement were not designed to lay down a wage for a particular job, irrespective of race.

The Wage Act

The Wage Act, the final industrial measure, provides for the creation of a permanent wage board which may make investigations into the conditions of any particular trade or industry on application to it by a representative body of employers or workers in the trade or industry concerned, or on a reference issued to it by the Minister.

The board, having investigated, reports to the Minister and may make a recommendation as to the wages and conditions which should apply in the particular sphere under reference. The Minister may accept such a recommendation, publish it for objection, cause such objections to be considered, and gazette it in order to give it the force of law.

Thereafter the recommendation becomes a determination and has the same force as an industrial agreement, save that it is not administered by an industrial council, but by the Department of Labour whose inspectors are responsible for seeing that it is carried out.

The Wage Act is usually brought into operation in relation to unorganised trades or industries or in the interests of the class of workers (natives) who are not classified as employees falling under the scope of the Industrial Conciliation Act.

Conclusion

The foregoing very brief summary of some of the main provisions of the industrial legislation of the Union serves to indicate the wide scope of the Acts, in their relation to industrial welfare. It indicates also that the social legislation of South Africa is abreast of and in some cases ahead of that in operation in many older industrial countries. It takes cognizance, too, of the peculiar social conditions of South Africa, where the wage gap between skilled and unskilled occupations has always been wide—although there is a strong tendency now to narrow the gap—and where there is a natural tendency for occupations to fall into two categories: those generally carried out by employees enjoying a civilised standard of living, and those (such as labourers' work) which are usually carried out and remunerated on a lower scale.

Catalogue Received

Pig-Iron. As a matter of general policy, it is desirable to make customers conversant with the works and methods of production just as much as with the properties of the product itself. Such a method has just been successfully carried out by the United Steel Companies, Limited, in connection with Workington and Distington machine-cast hematite irons. Quite a large proportion of a 30-page well-illustrated brochure is devoted to a description of the works, some details of the raw materials it mines and uses, and the plant employed. In this last connection some excellent illustrations are given of the pig-iron casting machine. The part of the brochure dealing with the properties of the pig-iron is both readable and convincing. The arguments put forward are reinforced by photomicrographs, certified test results and a range of photographs of actual castings made. Finally, details are disclosed of an advisory service to customers. With the brochure was enclosed a leaflet which summarises the advantages shown by the pig-irons in question. The brochure is a particularly interesting and worth-while addition to trade literature and fortunately it is available to our readers on writing to the Publicity Department of the United Steel Companies, Limited, the address of which is 17, Westbourne Road, Sheffield. 10.

The Week's News in Brief

Trade Talk

A WOOD STORE at the works of the Sterling Manufacturing Company, of Cubitt Town, London, E.14, was destroyed by fire last week.

C. & M. WELDING COMPANY, LIMITED, have removed from Cayton Street, London, to larger premises at Thames Road, Barking, Essex.

A NEW RANGE of medium-speed, cold-starting vertical oil engines has been introduced by Ruston & Hornsby, Limited, to replace their present VR series.

VICKERS (AVIATION), LIMITED, and Supermarine Aviation Works (Vickers), Limited, have been registered as private companies, each with a nominal capital of £100 in £1 shares.

RICH MOLYBDENUM-ORE DEPOSITS have been found in the Vosges around the Ballon d'Alsace. The ores are stated to be richer than those found in Algeria. Prospecting under Government supervision is continuing.

AN AIR-RAID REHEARSAL by the staff of Babcock & Wilcox, Limited, at Renfrew, was carried out on August 9. There are 20 underground shelters, each holding 50 persons, and 1,000 men and women took cover in less than four minutes after the warning.

OWING TO the expansion of their business, the Midland Monolithic Furnace Lining Company, Limited, have found it necessary to move into larger premises. From now onwards correspondence should be addressed to Black Seam House, St. Johns, Narborough, Leicester.

SUBJECT TO approval from shareholders of Thomas & Clement, Limited, ironfounders, Morfa Engineering Works, Llanelly, a scheme will come into operation shortly to amalgamate that company with the Glanmor Foundry Company, Limited, steel, iron and roll founders, also of Llanelly. Shareholders in the latter company have already approved of terms for the merger, which include the proposition that, as a preliminary to amalgamation, a company should be formed that would hold all the share capital of the two companies, amounting to £100,000.

NORTH-EASTERN TRADING ESTATES, LIMITED, most of whose factories at Team Valley and other centres are producing peace-time goods, has 145 tenants, an increase of three on last month, of whom 110 are in production, employing 3,720 people, which is 447 more than the number employed on June 30, a record monthly increase. There are also 538 men engaged on building work. Among the new tenants are manufacturers of aeroplane components. It is the first aircraft factory to be built in the North-East, and has obtained good contracts from the Air Ministry. Starting with a nucleus of 100 men, it is expected to employ four times that number after six months.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"ARMOID."—Metals and alloys in strip, rod and wire form, for use in welding. The Quasi-Arc Company, Limited, Thames House, Millbank, London, S.W.1.

"G.E.C."—Metal castings. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2.

"MAGNEDUR."—Magnesium metal and alloys. Dürener Metallwerke Aktiengesellschaft, c/o Boult, Wade & Tennant, 111 and 112, Hatton Garden, London, E.C.1.

"MOLDREX."—Chemical preparations for the treatment of foundry cores and moulds. The District Chemical Company, Limited, 52 to 54, Leadenhall Street, London, E.C.3.

"SOROH."—Machines for making centrifugal castings and for working up such castings. Aktiengesellschaft Oederlin & Cie. c/o W. H. Beck & Company, Morley House, 26/28, Holborn Viaduct, London, E.C.1.

Personal

MR. CHARLES GUEST, foundry engineer, has changed his address from Northampton to 11, Bath Row, Stamford, Lincs.

MR. W. H. COOK, chief buyer for the General Electric Company, Limited, at Coventry, has retired at the age of 69, after 52 years with the firm.

MR. HERBERT MATHER, an employee of the Rutland Foundry, Ilkeston, Derbyshire, last week completed the record of 67 years' service with the firm. He is 79.

MR. F. LE NEVE-FOSTER has been appointed to the board of Crompton Parkinson, Limited. Mr. Le Neve-Foster has been associated with the company for many years. He is also a director of the Stanton Ironworks Company, Limited.

MR. RICHARD SHARPE, assistant blast-furnace manager at Dorman, Long & Company's Acklam Works, Middlesbrough, has left England to take up a position as general blast-furnace manager of the new £3,000,000 steelworks at Karabuk, Turkey.

MR. MARTIN MACKAY, a pipe moulder in the employ of the Scottish Central Iron Foundry at Camelon, Falkirk, was last week made the recipient of the Honorary Testimonial on parchment of the Royal Humane Society, for having saved a young lad from drowning.

Wills

LAWRENCE, A. L., managing director of Dewrance & Company, Limited, engineers	£24,589
RUSTON, LIEUT.-COL. JOSEPH SEWARD, of Lincoln, chairman of Ruston & Hornsby, Limited	£81,013
WILKINSON, MENCE, chairman of the Central Provinces Manganese Ore Company, Limited, and the United Kingdom Ferro-Manganese Company, Limited	£47,049
BREARLEY, HORACE, a director of J. J. Habershon & Sons, Limited, steel rollers, Rotherham, and of W. T. Beesley & Company, Limited, Universal Steelworks, Sheffield	£9,020

Obituary

MR. M. K. INGOLDBY, a director of the Variable Speed Gear, Limited, Newcastle-upon-Tyne, a company under the control of Vickers-Armstrongs, Limited, has died at the age of 50.

MR. FREDERICK WM. BROOKE, a director of the Cleveland Magnesite & Refractory Company, Limited, of which company his father, Mr. F. H. Brooke, is chairman, died last week as the result of a motor-car accident.

MR. JAMES HINDE, process superintendent at the works of the British Aluminium Company, Limited, Burntisland, has died suddenly. He had been with the firm since 1915, and was 60 years of age.

THE DEATH has occurred of Mr. Peter Murphy, of Sunny Hill, Milford, at the age of 77. A native of Falkirk, Mr. Murphy went to Belper about 33 years ago to take up a position as foreman with the Park Foundry Company, Limited. He retired about 10 years ago.

MR. JOHN LYNN, a Greenock foreman moulder, lost his life on Monday in an attempt to put out a chimney fire in the Caledonian foundry, where he was employed. When the alarm was given Mr. Lynn climbed to the roof and with the aid of extinguishers put out the flames. Collapsing on reaching the ground, he was removed to the infirmary, but died shortly after admission.

MR. C. E. G. HOUSE, M.B.E., a principal officer of the Department of Overseas Trade, who was especially interested in engineering developments likely to be of value to our export trade, died last week, aged 55. Mr. House, who was a Whitworth Exhibitioner, was trained at H.M. Dockyard at Chatham and the Imperial College of Science. He was later assistant examiner at the Patent Office. During the War he represented the Board of Trade and the Department of Overseas Trade on the Priority Committee of the Ministry of Munitions.

MR. A. C. CROSSLEY, M.P., a director of Crossley Bros., Limited, Openshaw, and of Crossley-Premier Engines, Limited, Nottingham, was killed on Tuesday when the air-liner in which he was flying to Copenhagen crashed into the sea off the Danish mainland. Mr. Crossley, who was 36, was the only son of Sir Kenneth Crossley, Bt., chairman of Crossley Bros. He took an active part in politics, being M.P. for Oldham from 1931 to 1935, and subsequently representing the Stretford Division of Lancaster. He was Parliamentary Private Secretary to Captain A. U. M. Hudson, Parliamentary Secretary to the Ministry of Transport. Among the various books Mr. Crossley had written was one on salmon fishing, in which sport he was an expert.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Fulgo Metals, Limited, 3/9, Southampton Row, London, W.C.1.—Capital, £3,000. Metal merchants, etc.

Robert Normansell, Limited, 2, Exeter Street, Birmingham.—Capital, £5,000. Malleable-iron founders. Directors: H. Hall, C. I. Thomson, and K. G. Thomson.

Special Testing Works, Limited.—Capital, £2,000. Testers and advisers in connection with the production of special steels, etc. Directors: B., G., A. K., and D. Beardshaw, 456, Abbey Lane, Sheffield.

Contracts Open

Stoke-on-Trent, August 21.—Pipes and gullies, cast-iron work, cast-iron pipes and specials, etc., for six months ending March 31, 1940, for the Town Council. The City Surveyor, Town Hall, Stoke-on-Trent.

Scunthorpe, August 21.—Provision and laying of about 5,344 yds. of 15-in. dia., and 3,650 yds. of 10-in. dia. spun-iron pipes, for the North Lindsey Water Board. Mr. W. Farrar, engineer, Council Offices, Scunthorpe. (Fee £4, returnable.)

Company Reports

Modern Machine Tools, Limited.—Interim dividend of 7½ per cent.

Lochgelly Iron & Coal Company, Limited.—Dividend of 12½ per cent.

Hadfields, Limited.—Interim dividend on the ordinary shares of 7½ per cent.

Geo. Adlam & Sons, Limited.—Net profit for the year ended March 31 £18,900; debit balance brought in, £15,383; depreciation, £2,160; debit balance carried forward, £1,584.

A.F.A., 1940, Convention in Chicago

The Board of Directors of the American Foundrymen's Association have accepted an invitation from Chicago to hold its next Convention in that city from May 6 to 10, 1940. Simultaneously there will be an exhibition of foundry equipment and supplies in the halls of the International Amphitheatre of the Union Stock Yards & Transit Company.

As Chicago is a leading foundry centre, it is expected that the Convention will exceed in interest and attendance any previous Convention. Committees of the Chicago Chapter and of the Association are already being planned to provide works visits and technical sessions of the highest order. The daytime sessions will be held in the meeting rooms of the Stock Yards Inn, Saddle and Sirloin Club and the Amphitheatre. Evening meetings will be held at the Palmer House, which will be the headquarters hotel.

Raw Material Markets

The iron and steel industry is assured of a very active autumn and the position is such that most producers have restricted holidays this year as much as possible. Some works are maintaining continuous activity, while others are stopping only for essential repairs and overhauls. Orders in connection with the rearmament programme are keeping a large number of works fully occupied, but there is also a steady demand for ordinary industrial requirements.

Pig-Iron

MIDDLESBROUGH.—Holidays are being taken in this area this week, but little inconvenience is caused thereby to the Cleveland iron trade. The current production of foundry iron is very small, but the demand is still at a low ebb and no difficulty is met in meeting orders from stock. Many local consumers are placing orders with Midland makers of iron, as supplies from that source are obtainable at lower prices than those quoted for Cleveland material. Export trade, too, is precluded as a result of the lower quotations ruling on the Continent. Stocks of hematite at the makers' works are being steadily reduced and trade in this section is very satisfactory. Contracts extend over the next few months and the outlook for consumption is promising. Deliveries to Sheffield and South Wales are on a good scale, but foreign business is restricted to special grades of hematite.

LANCASHIRE.—Holidays continue to affect the market in this area and new business in foundry iron has been within narrow compass during the past week or so. In addition, there has been a fairly large number of delivery suspensions. An absence of forward transactions is noticeable and any new orders placed are for small tonnages for early delivery. Only the machine-tool makers and the heavy electrical engineering concerns have continued to take up supplies on a satisfactory scale. Jobbing foundries are slightly better situated in some instances, but the light-castings trade generally is very quiet and is now entering upon the usually slack period of the year. Deliveries of hematite have been maintained and consumption may be expected to remain at a satisfactory level for a considerable time to come.

MIDLANDS.—Holidays at most consuming works in this area have been curtailed, but the light-castings section has generally taken the normal vacation, as work on hand is not sufficient to justify continuous operations. There is only a small current demand for high-phosphorus iron and consumers' needs are easily met from stocks. Engineering foundries in most cases made an early return to work and they continue to place substantial specifications for deliveries of low-phosphorus and hematite irons. Supplies of the latter are fully ample to meet requirements, but low-phosphorus iron is only on hand in comparatively small tonnages at most producers' works and there is the possibility of a slight shortage later in the year. Nevertheless, plentiful supplies are available in Scotland, where the local demand is quiet, owing to the non-competitive nature of prices there.

SCOTLAND.—The light-castings trade is still disappointing, while most other consumers of foundry iron are not working so well as might be desired. The demand for iron, nevertheless, has shown a slight improvement of late, but there is a lot of leeway to recoup before business can be described as satisfactory. Pressure for steelmaking irons is unabated and both basic and hematite are being taken up in good tonnages by the steelworks.

Coke

Despite the recent activity in the foundry-coke market, business is still at a fairly high level. Consumers appear to be keen to cover their requirements over the remainder of the year. For delivery to Birmingham and district up to December 31, the minimum quotation for both Durham and Welsh coke is 50s. 6d. per ton.

Steel

The demand for steel in the North-East area is such that many works are remaining in operation this week, which is usually taken as a holiday on account of the Stockton Races. Producers in other districts are also working to capacity and consumers continue to press for early deliveries. Delays in the despatch of certain descriptions of steel is inevitable and is having to be tolerated by consumers, but users are receiving supplies as soon as they become available. The sheet trade is dominated at the present time by the requirements of the A.R.P. programme and galvanised sheets are taken up in heavy tonnages for the production of shelters. Structural steel, too, is moving away as supplies are offered and consumers continue to be fully occupied. Plates and sections for the shipbuilding trade are in substantial demand, especially in Scotland, where a considerable amount of Admiralty work is on hand.

Scrap

While the demand for steel scrap is rather less insistent than it was a few weeks ago, available supplies are heavily contracted and a continuance of the present conditions is assured for a considerable time to come. There is a steady call for iron scrap, but ample supplies are generally offered.

Metals

Copper.—On Thursday last it was announced on behalf of the copper producing companies operating under the restriction scheme that from August 16 production would be increased from 95 per cent. to 105 per cent. of the basic tonnages. Following this announcement prices fell away to some extent. The 10 per cent. quota increase will, it is estimated, raise supplies by between 5,000 and 6,000 short tons a month. In view of the current rate of consumption it is expected that these additional supplies will be taken up without difficulty. Business of late has been rather quieter, due to a large extent to holidays. It is announced that world stocks of refined copper during July decreased by 23,670 short tons to 490,000 tons. The apparent world consumption totalled 181,000 tons, while the world output by mines and smelters amounted to 164,000 tons. The world production of refined copper was 158,000 tons.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £44 5s. to £44 6s. 3d.; Friday, £44 2s. 6d. to £44 3s. 9d.; Monday, £44 7s. 6d. to £44 10s.; Tuesday, £44 7s. 6d. to £44 8s. 9d.; Wednesday, £44 6s. 3d. to £44 7s. 6d.

Three Months.—Thursday, £44 7s. 6d. to £44 8s. 9d.; Friday, £44 2s. 6d. to £44 3s. 9d.; Monday, £44 7s. 6d. to £44 10s.; Tuesday, £44 8s. 9d. to £44 10s.; Wednesday, £44 7s. 6d. to £44 8s. 9d.

Tin.—With the market under the control of the buffer pool authorities, there is little to report concerning this metal. There is a steady demand in this country and also on the Continent, but business in the United States is still disappointing. The tinplate mills in that country are now operating at around 70 per cent. of capacity, which is very satisfactory, but most other working-up industries are not taking deliveries as freely as might be expected.

Official quotations were as follow :—

Cash.—Thursday, £229 17s. 6d. to £230; Friday, £229 17s. 6d. to £230; Monday, £229 17s. 6d. to £230; Tuesday, £229 17s. 6d. to £230; Wednesday, £229 17s. 6d. to £230.

Three Months.—Thursday, £225 5s. to £225 10s.; Friday, £225 5s. to £225 10s.; Monday, £225 5s. to £225 10s.; Tuesday, £225 to £225 5s.; Wednesday, £225 5s. to £225 10s.

Spelter.—There is little apparent change in this market since the holidays; the demand from the galvanising concerns is still at a good level and, on the whole, the outlook is not unsatisfactory, although the general demand at the present time is not heavy. Trade on the Continent is firm, while the American market, too, is quite satisfactory.

Daily market prices :—

Ordinary.—Thursday, £14 7s. 6d.; Friday, £14 6s. 3d.; Monday, £14 8s. 9d.; Tuesday, £14 10s.; Wednesday, £14 8s. 9d.

Lead.—A firm tone has continued to prevail in this market, with demand at a good level, and consumption is reported to be fully maintained. Pressure for prompt metal is sustained.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 18s. 9d.; Friday, £15 17s. 6d.; Monday, £15 16s. 3d.; Tuesday, £15 15s.; Wednesday, £15 15s.

Scrap.—There has been quite a brisk tone in non-ferrous scrap business, which is somewhat unusual at a time when many works are idle owing to holidays. German consumers, also, have been in the market for substantial tonnages.

Approximate selling prices for old metal are as follow :—New aluminium cuttings, £74; rolled, £62; cast, £31 to £35; foil, £80. Copper, £40 to £44; braziery, £38. Brass (clean), £24 to £27. Zinc, £11. Lead, £15 5s. Gunmetal, £40.

Company Meeting

Davy & United Engineering Company, Limited

The annual meeting of Davy & United Engineering Company, Limited, was held on Friday last in Sheffield. MR. E. J. FOX (the chairman), who presided, referred to the increase in the volume of business which the Sheffield works had undertaken. In 1935-36 industry was just emerging from a period of depression, and in the three years since then the firm had taken orders which totalled over £2,000,000. It was obvious that had they not extended their shops and increased their capacity as they did, a considerable amount of that business would have been lost, not only to the company but in all probability to the country. The work to which he had referred related to commercial business both for home and export, and was not directly the result of the Government's rearmament policy. The Sheffield works had again been employed to full capacity, and while their roll business in Middlesbrough was also satisfactory they suffered a recession in the demand for steel castings in common with other foundries. This business was now showing an upward trend and as a result of the improvements which had been effected in their steel foundry that branch was able to supply a greater volume of the requirements of their own engineering shops, as well as cater for the outside market. The firm had entered into an agreement to acquire the whole of the share capital of Duncan Stewart & Company, Limited. The board had felt that if we in this country were to recover and maintain our position as the foremost builders of steelworks plant for satisfying the requirements of this country and of foreign countries, we were required to create a group strong in management, in technical personnel, and in designing ability, and with sufficient works capacity to give reasonable deliveries to our customers. The firm had taken steps to achieve this by extending the Sheffield works, by linking up with United Engineering & Foundry Company, and by acquiring the allied business in Middlesbrough. Now, by the acquisition of Duncan Stewart & Company, Limited. The board had felt towards that aim by adding to their personnel and works capacity and by merging specialised knowledge of steelworks plant. Duncan Stewart & Company, Limited, had a good reputation in the industry particularly in the manufacture of forging presses, and this recent fusion of interests formed a group capable of designing and building a complete range of steelworks equipment. The consideration which was being given for the Duncan Stewart capital was 125,000 shares of the Davy & United Company and they were acquiring fixed assets of a book value of £120,000 and net liquid assets valued at £80,000. It was proposed that Mr. J. B. Talbot-Crosbie and Mr. W. Kilpatrick, directors of the Duncan Stewart company, should join the Davy & United board. Speaking of future prospects, Mr. Fox said that in the absence of any major disturbance the current year should be no less satisfactory than the past year. At an extraordinary general meeting held subsequently, the capital of the company was raised from £500,000 to £750,000.

A.S.T.M. Standard Test-Bar

The Cast Iron Committee (A.3) of the American Society for Testing Materials has recommended the withdrawal of the Standard Specifications for the Arbitration Test-Bar and Test Specimen for Cast Iron (No. 124-29) on the proposal of the Sub-committee (VI) on General Castings.